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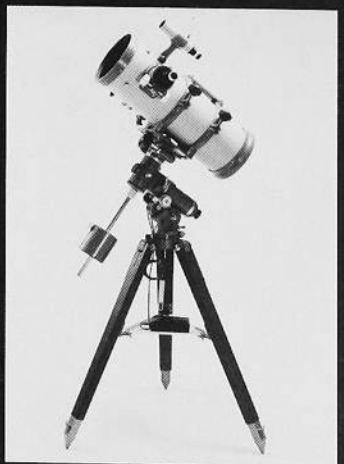

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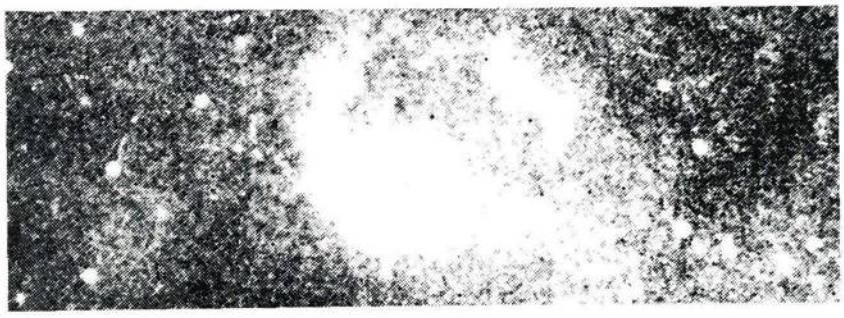
DEEP SKY

Taking Your First Piggyback Astrophotograph
by Rick Dilsizian

8 *If you have a clock-driven telescope on which you can mount a camera, why not record images of your favorite deep-sky objects? Piggyback astrophotography requires minimal effort, yet it can produce stunning results.*

Treasures of the Unicorn
by Phil Harrington

14 *If you had to name your favorite winter constellations, chances are Monoceros would not be one of them. However, the Unicorn holds a relatively large number of unusually bright clusters and nebulae — and even a few galaxies.*



Outbursts of FU Orionis Stars
by Ken Croswell

21 *In 1936 a 16th-magnitude star in Orion exploded in brightness. By early 1937 the star shone at 10th-magnitude, and it remains at this brightness today. FU Orionis is one of only five stars to behave in such a manner.*

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ON THE COVER: The richest, most complex region in Monoceros is that of the Cone Nebula (NGC 2264). In this photo the Cone appears as a dark object south of the bright nebulosity. Also visible in the picture is NGC 2261, Hubble's Variable Nebula, at bottom center. Photo by Al Lilge (6.9-inch f/3.5 lens, 30-minute exposure on 098-04 film with a red filter.)

Inside View

Two Departing Friends

This issue marks the departure of two members of the *Deep Sky* staff who have worked hard in the past to bring you the best in deep-sky observing. Glenn F. Chaple, Jr., has written this magazine's column on double stars ever since its inception in 1982 as well as the predecessor to the column in *Deep Sky Monthly* between 1977 and 1982. Glenn is one of the three longest-term contributors to this magazine. His interests have shifted from double stars to variable stars, and so he is turning over the double star column to Brian Skiff, another long-term *Deep Sky* contributor.

Also departing after this issue is Jeff Kanipe, our in-house associate editor. Jeff has helped to edit *Deep Sky* over the course of six issues but now finds himself too busy with other projects to continue.

Deep Sky will miss the talents of both Glenn and Jeff but wishes them luck in other pursuits and hopes they'll become occasional contributors to our pages when time permits.

This issue brings you the beginning of a series on basic deep-sky photography by our contributing editor and expert photographer Rick Dilsizian. This month's lead feature explores the potential of piggyback astrophotography for recording deep-sky objects of relatively large sizes. Future articles in the series by Rick will appear over the next two years and will cover more advanced techniques like through-the-scope photography, films and filters to maximize image quality, Schmidt camera photography, and tricks of the trade that will help you produce the best possible photos.

Following Rick's piece, Phil Harrington takes you through an exhaustive tour of Monoceros the Unicorn. You may know Monoceros holds such deep-sky treasures as the Rosette Nebula, the Cone Nebula and associated nebulosity, star cluster M50, and Hubble's Variable Nebula. However, Monoceros also holds dozens more attractive deep-sky objects visible in small telescopes, including many bright open clusters and even a few faint galaxies. Complete data for these objects appears in a table on page 18.

Harvard's Ken Croswell has contributed an unusual astrophysical detective story that follows astronomers' knowledge of FU Orionis stars. In 1936 FU Orionis was discovered to be a bizarre flare star; now five such stars are known and astronomers are trying to understand the physical processes that drive these rare stars to explode in brightness.

The columns in this issue offer a strange combination of delightful articles. Well-known Canadian astrophotographer Jack Newton relates his excitement in recording the "facial" details in the Clown-Face or Eskimo Nebula, NGC 2392 in Gemini. Jack's perseverance and determination in making what may be the best backyard photo of this object yet produced should instill some "get up and go" in the astrophotographers among *Deep Sky*'s readership.

Another well-known astrophotographer, Robert Reeves of San Antonio, proposes that we as deep-sky observers adopt some new nicknames for objects that may not be so familiar to many of you. This raises the question of "where will it end?" It also makes the point that many objects in the sky might be better remembered if they could be related to human experience.

Finally, Massachusetts observer Gerry Dyck describes his method of observing and plotting by computer the variations of cataclysmic variable stars. The simplicity and amazing success in producing data Gerry has had at his High Hill Observatory should serve as a lesson to all who aspire to observe variables.

Yours truly,

Dave Eicher
Editor-in-Chief

Letters to DSM

Happy Tenth

Hello Dave / Congratulations on ten years of *DSM*! I have just reviewed my file of your early issues, together with our correspondence back in 1977. I reread my little contribution to *DSM*, vol. 1, no. 2. I have all of the issues you sent me and cherish them highly. "You've come a long way, baby!" Good luck as you continue the fine tradition.

Dr. Jay Gunter
1411 North Mangum Street
Durham, NC 27701

Happy Tenth, but . . .

Dear *Deep Sky* / Congratulations on reaching your tenth anniversary! I've only known about *Deep Sky* for the past two years, but I've been a faithful reader ever since I discovered it. On a less upbeat note I found it sadly ironic that you chose your tenth anniversary issue to begin printing advertisements. I know all the arguments *for* advertising, but it was nice to read a good magazine that didn't contain any.

Everett Carter
88 School Street
North Kingston, RI 02852

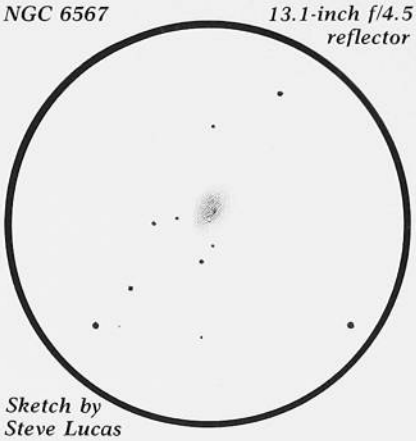
Dear Mr. Carter / I appreciate your congratulations very much. Believe me, I enjoyed having a 100 percent editorial product as much as you enjoyed not seeing advertisements. However, business is business and advertising is back. Deep Sky *carried advertising up until about three years ago, when we closed a deal with a major telescope manufacturer to supply the magazine as a premium for its customers. Obviously the manufacturer didn't want competing ads in the magazine, so we supplied an ad-free journal to the company and to you as a subscriber. This year the company, affected by the post-Halley slump in telescope sales, did not renew the arrangement. So ads are back in* Deep Sky. *However, there's a good side to all of this. No matter how many ads we carry,* Deep Sky *will retain forty editorial pages and at some point add more editorial material if enough advertising comes in. The ads should ideally provide a service to readers looking for fine products to use in their pursuit of astronomy. But if you must look at the ads as a detriment, know that at least potentially this cloud has a bright silver lining.* — DJE.

Supernova Sighting

Dear Dave / On the morning of July 26, 1987, James Dana Patchick of Culver City, California, discovered a magnitude 13.5 star in the barred spiral galaxy NGC 2336. This is the first supernova spotted as part of the Sunsearch amateur network, and we are all proud of Dana and his success.

Dana confirmed the discovery sighting on August 16, and forwarded the information to the Sunsearch network. A day later James T. Bryan of Georgetown, Texas, sent a telegram to the Central Bureau for Astronomical Telegrams. The object was to be designated Supernova 1987L.

On August 17 a spectrum was made by Michael Strauss of the University of



Sketch by Steve Lucas

California at Berkeley under the direction of Alex Filippenko. The astronomers used the 3-meter Shane telescope at Lick Observatory. Within two hours the astronomers confirmed the object was a type II supernova. At the end of August the supernova was one or two months past maximum light and showed very strong hydrogen-alpha lines. It is expanding at a rate of 11,000 kilometers per second. NGC 2336's distance modulus is 31.6, so the supernova is somewhat brighter than theory predicts for this galaxy. We hope cooperative observers affiliated with the Sunsearch network will discover many more supernovae!

On other matters, I enclose an observation of a little-known deep-sky object in Lyra, NGC 6765. This object was recognized as a planetary nebula by Rudolf Minkowski in 1946 and is completely overshadowed by the Ring Nebula. I rarely hear observers talking about this object or see references to it. NGC 6765 is not easy to see but nevertheless well worth searching for.

While looking at your map of the M13 area on page 9 of the summer *Deep Sky*, I couldn't help noticing the absence of a very obscure object that lies near M13. The distant galaxy IC 4617 has a photographic magnitude of about 15 and is barely visible in some large amateur telescopes. I am enclosing a reference chart showing the galaxy's position some 15' northeast of M13. Three of my friends have spotted this little object, Dana Patchick among them.

Incidentally, I really enjoyed reading about your and Alan Goldstein's voyages in the article by Alan!

Steve Lucas
14400 South Kolin Avenue
Midlothian, IL 60445

Dear Steve / Congratulations to Dana Patchick and the Sunsearch network for the NGC 2336 supernova. I know that many more such discoveries are to come. — DJE.

Vivid Color in M42?

Dear Sir / The other night I was using my 10.1-inch f/4.5 Dobsonian to observe the Orion Nebula during several periods of exceptionally good seeing. The night was clear and very cold, and Orion was almost overhead. With my 40mm Plossl eyepiece I noticed the lime-green color in the nebulosity right away, but later in the night I noticed some purple tinges around the nebula's edges. A few people I have talked to have said the purple is not supposed to be visually detectable. Was this just my imagination?

Steve Komp
2902 Lincoln Road #11
Hattiesburg, MS 39401

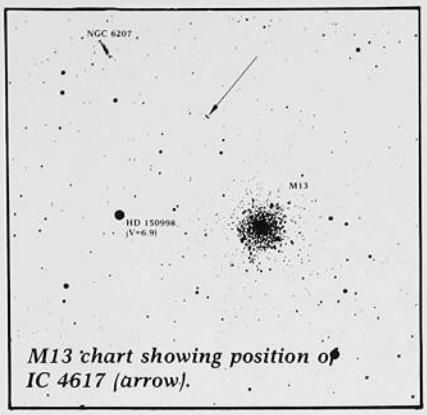
A Response from Skiff

Dear Dave / Mr. Dave Gard's letter in the spring issue about two bright globulars in the Andromeda Galaxy impels me to correct an error I knew about even before the article discussing them was published three years ago.

The objects called G289 and G295 were catalogued as globulars by Sargent *et al.* in a 1977 paper based on examination of Palomar 1.2-meter Schmidt plates. Later surveys with larger scale plates show both these objects are stars, however.

The fainter star (G289) was measured photoelectrically by the Russian astronomers Sharov and Lyuty, who found V = 12.57, B-V = 1.06, and U-B = 0.80. These numbers correspond to a K-type dwarf at about 200 parsecs distance or a slightly reddened G8 giant at around 3 kiloparsecs (a less likely possibility).

There are no similar measures in the literature for G295, so on the morning of July 6, 1987, I made a quick measurement of the two stars in the course of my regular work with the Lowell Observatory 21-inch telescope. I meas-



M13 chart showing position of IC 4617 (arrow).

ured the two stars with a Stromgren *y* filter (similar in effective bandpass to Johnson V) simply to determine the difference in magnitudes. This came out to be 0.48. The formal error was less than 0.01, but this was a lucky fluke to be taken with a grain of salt: the value above is probably only good to 0.05 magnitudes.

Thus G295 has a V magnitude of about 12.1, very close to what Mr. Gard estimated.

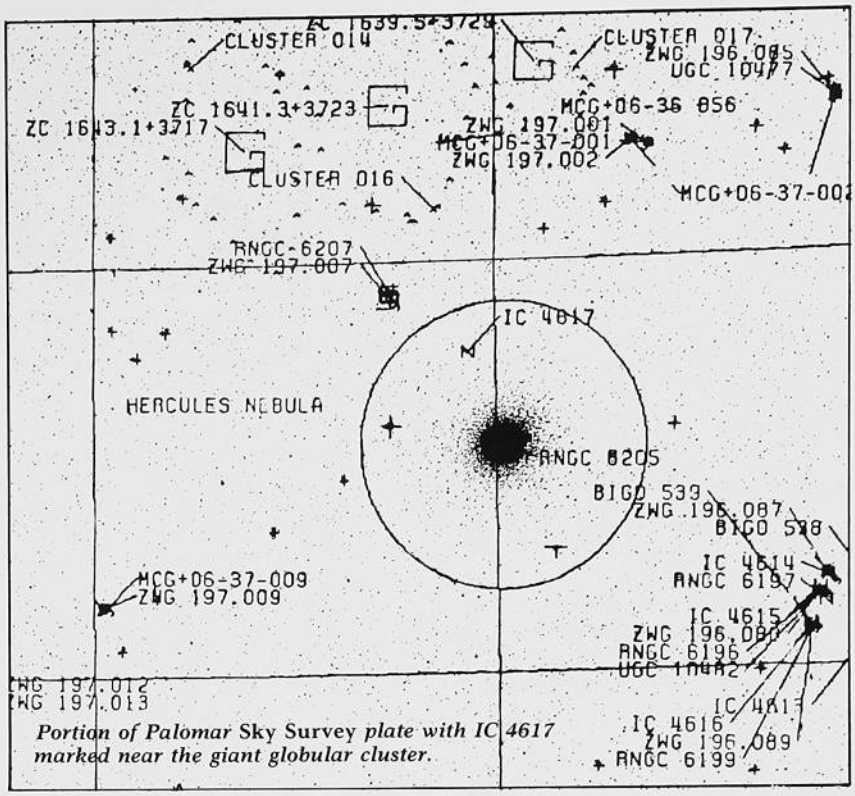
Brian Skiff
421 West Aspen
Flagstaff, AZ 86001

Really Faint Stuff around M13

Dear Dave / I enjoyed the summer issue very much, and it brought to mind several experiences I've had as an astrophotographer. Using 16-inch and 20-inch scopes for most of our photography, Pierre Schwaar and I occasionally notice faint, unusual objects in the fields of brighter objects we're photographing. In fact, a most intriguing object recently showed up near M13 that is not on your finder map in the summer issue.

While many observers are aware of NGC 6207, the faint spiral 30′ northeast of M13, few have seen IC 4617. This is a 16th-magnitude Sb-type spiral just 15′ northeast of M13 within the same field as outer stars of the globular. On photographs IC 4617 appears as a small edge-on spiral touching the corner of a small trapezoidal group of stars. In a photo taken with our 20-inch telescope, a hint of a dust lane was detected. While not visible in 8-inch and 10-inch telescopes, the galaxy did show up in my 12.5-inch f/5 telescope as a very dim streak. The 20-inch telescope shows a stellar nucleus in this galaxy with a gradual fading ot surface brightness to the edges.

IC 4617 was first reported to J. L. E. Dreyer by E. E. Barnard in the early 1900s. The description for this galaxy in the *Index Catalogue* reads: "Small, elongated in p.a. 29°, bright middle." IC 4617's size is about 1.1′ by 0.4′, and it lies 14′ from NGC 6207 and 14.5′ from the center of M13.



Portion of Palomar **Sky Survey** *plate with IC 4617 marked near the giant globular cluster.*

Unfortunately most professional observatory shots of M13 are centered on the core and this galaxy lies just outside the field. Only on deep amateur photos or large Schmidt pictures does IC 4617 appear clearly and even then is often overlooked because of M13.

Enclosed is a copy of the *POSS* showing the appropriate field.

Chris Schur
HCR Box 952
Black Canyon City, AZ 85324

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Basic Astrophotography Part I: Taking Your First Piggyback Astrophotograph

by Rick Dilsizian

Did you ever open *Deep Sky Magazine* and say, "I wish I could have taken that shot of M42!" or "Why didn't my photo of the Ring Nebula ever turn out like that?" Have you ever wondered why your polar alignment, focusing, or guiding isn't up to snuff? If so, read on: relief is just an article or two away!

In future issues we will cover the field of astrophotography — from the basics of piggyback work to more specialized areas including prime focus, Schmidt camera, and cold camera use. We will also explore different film types, hypersensitization, and selective filtration and film processing to see if we can enhance image contrast and quality. Then we'll evaluate different types of errors made both by beginners and advanced astrophotographers in the pursuit of the sharply focused, accurately guided, and perfectly exposed astronomical negative or slide.

We'll begin with the simplest of all methods — piggyback astrophotography. In piggyback astrophotography you make wide-field exposures with a camera mounted on top of your telescope while you guide on a star in your telescope.

Basic Equipment

To do piggyback astrophotography you need the following equipment:

- A telescope with a clock drive.
- A drive corrector, preferably in both declination and right ascension.
- A guiding eyepiece with an illuminated reticle.
- A piggyback mount to connect your camera to the telescope.
- A camera, preferably a 35mm SLR.
- A cable release.

The game plan in piggyback astrophotography is to compose the field you want to photograph in the camera's view finder, find a suitable guide star within the camera's field that is also within the telescope's field of view, and make the exposure of that field while keeping the guide star in the center of the telescope's guiding eyepiece.

A clock drive is necessary to compensate for Earth's rotation. As Earth rotates, celestial objects move from east to west at an angular rate of 15° per hour. If we make an exposure of a starfield without compensating for this motion, the stars within the field trail across the film leaving lines of light. A clock drive tracks the stars at their sidereal rate, thus canceling out the the stars' relative motion on the film.

A dual-axis drive corrector is needed to make fine adjustments in two linear directions: east and west (right ascension) and north and south (declination). Because of atmospheric refraction, errors in polar alignment, and power fluctuations affecting the motor drive, you need to make minute positional changes in all four cardinal directions to accurately track celestial objects. This allows you to keep the guide star perfectly centered within your guiding eyepiece.

But keeping that guide star in the middle of the telescope's eyepiece is impossible without some frame of reference. You can't go by judgment alone! How can you be sure the guide star is *exactly* in the middle of the eyepiece? By using a special eyepiece with illuminated cross hairs that serve as a reference for guide star movement. This eyepiece is known as an "illuminated reticle" eyepiece.

The next piece of equipment you need is a good camera. Ideally the camera should have interchangeable lenses so you can selectively compose the field you wish to photograph, an infinity setting (inferior cameras have preset focal distances and a majority of times they are well below infinity), and a through-the-camera view finder so you can see exactly the photo you wish to take. In addition, the camera should also have a "B" setting on the exposure dial. This setting (the "B" stands for "bulb") permits you to take extended time exposures by allowing the shutter to remain open for long periods.

But how can you do this with your finger, guide, and not shake the camera? This is where a cable release comes in handy. A cable release is essentially an extension cord for the shutter. When you press the cable release button at one end, the shutter button (to which the other end of the cable is attached) is depressed and the shutter is opened, thereby permitting exposure. Once you are finished exposing, you release the locking mechanism on the cable release button, which releases the shutter button and ends the exposure.

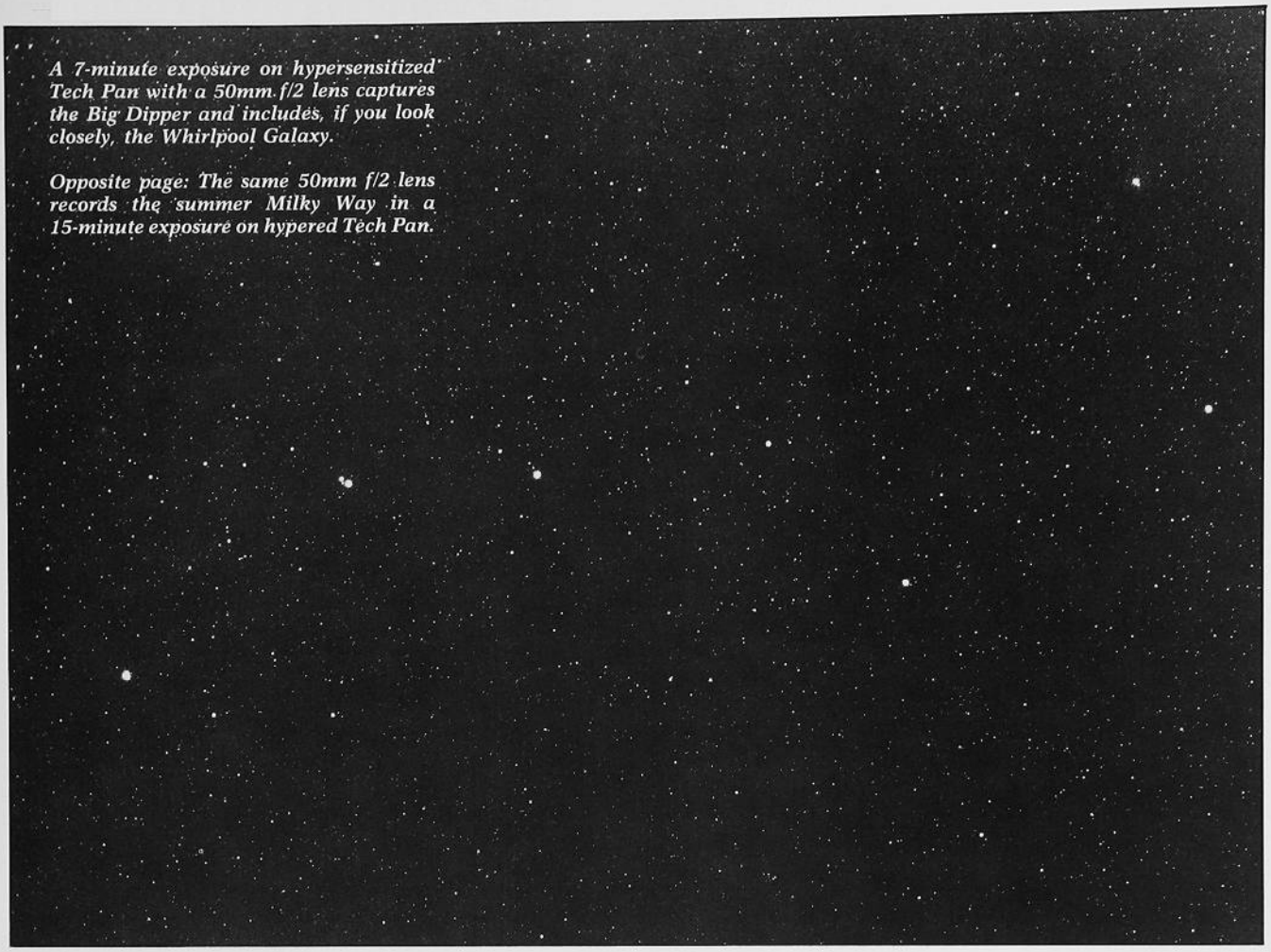
The next step is determining which lenses you should use for piggyback astrophotography. This depends on the composition of the sky fields you want to photograph. The rule is that the smaller the focal length of the lens, the greater area of sky you can photograph. The table on page 11 should help you determine the lens type best suited for a relevant subject.

A Piggyback Checklist

In the previous section we examined what is needed to take deep-sky photos. Are there special requirements for a piggyback photo? Let's say we want to get a constellation photo of Orion. Orion fits very nicely into the field of a 50mm lens (27° by 40°), so we put that particular lens on our 35mm camera. We connect our camera to the piggyback mount and mount the entire fixture onto our telescope. Let's now review what we have to do to take the exposure after aligning the telescope on the north celestial pole.

1. After the camera is attached, point the camera in the same direction as the telescope tube. Do not offset the camera's optical axis from the telescope's optical axis. If the camera and the telescope are not pointing in the same direction, the camera's field will "rotate" around the direction the telescope is pointing in the sky. Field rotation causes the star images to look like arcs.
2. Make sure your camera is loaded

This photo shows the major components of piggyback photography: the telescope (1), coupled with a motor drive (6), the illuminated reticle eyepiece (2), a piggyback mount (3), a 35mm SLR camera body (4) and lens (5), and a cable release (7) needed for time exposures. All photos by Rick Dilsizian.



A 7-minute exposure on hypersensitized Tech Pan with a 50mm f/2 lens captures the Big Dipper and includes, if you look closely, the Whirlpool Galaxy.

Opposite page: The same 50mm f/2 lens records the summer Milky Way in a 15-minute exposure on hypered Tech Pan.

LENSES AND SUBJECTS

Lens and Focal Length	Comments
Fisheye (7.5mm, 15mm)	Good for capturing the entire Milky Way from horizon to horizon because this lens covers up to 180 degress.
Wide Angle (20mm, 24mm, and 28mm)	Good for capturing vast regions of the Milky Way and comets with extremely long tails.
Normal (50mm)	Excellent for constellations because this lens covers 45 degrees (Orion, Big Dipper, Little Dipper, and Leo to name a few). A 50mm lens is also suited for sections of the Milky Way such as the Sagittarius and Cygnus star clouds, and the Large and Small Magellanic Clouds. Also good for comets with moderately long tails.
Telephoto (135mm)	Selective regions of constellations such as the Belt and Sword of Orion, the Pleiades and Hyades clusters, and the Virgo cluster of galaxies can be framed in the field of view of a 135mm telephoto lens.
Moderate Telephoto (200mm, 300mm)	Excellent for celestial portraits of many deep-sky objects. In order for a deep-sky object to qualify, it should have a fairly large angular diameter — on the order of a half a degree or greater.

with film. How would you like to take a forty-minute exposure of M8 and M20, expertly guided and focused, just to find out there was no film in the camera?

3. Set your lens on infinity and your camera's shutter setting on B. Set your 50mm lens to f/2.8, no matter what the maximum aperture is. This is because of another nasty phenomenon known as the "seagull effect." Because of off-axis aberrations, stars appear noticeably deformed along the edges of the field when a lens is used at maximum aperture (f/1.4, for instance).

4. Compose the photograph in the camera's view finder. Center the belt of Orion about midway in the field; this should put the whole constellation within the view finder.

5. Find a guide star in the telescope by moving around *slightly* in right ascension and declination. But be careful! If you move too much in any direction, you will disturb the composition of your picture.

6. Once you find a guide star, focus it as sharply as you desire for guiding. Some people like to defocus the guide star slightly; I prefer sharp focus. Position the guide star in the center of the cross hairs of your illuminated reticle.

7. Now check Orion again. Make sure it is still composed properly. If not, you

A 55mm f/4 lens shows the area around Gamma Cygni, including the North America Nebula and Deneb at upper left. This is a 45-minute exposure on hypered Tech Pan.

Opposite page: Also shot with a 55mm f/4 lens, this photo shows Orion's belt and sword. This is a section of a 45-minute exposure on hypered Tech Pan.

have found a guide star too far out of the field to be used. You will have to go back, recompose Orion with the camera's view finder, and search for another guide star. Don't try to reorient the camera to accommodate the guide star! To do so would misalign the camera's optical axis from that of the telescope's optical axis, and field rotation will result.

8. Orient the cross hairs of the telescope's guiding eyepiece to right ascension and declination. You do this by turning off the motor and monitoring the star as it slides across the eyepiece's cross hair. Simply rotate the eyepiece so one cross hair is parallel to the direction of this movement. The cross hair then represents right ascension and the other represents declination. If the guide star wanders off in any direction while you are guiding, your eye will be able to quickly deduce the amount and direction of correction in right ascension or declination that needs to be applied.

9. At this point, recheck the camera focus to make sure the lens is on infinity, the lens is at the correct f/stop, and your camera is on the "B" shutter setting.

10. Holding the guide star steady on the cross hairs in the telescope, reach for the cable release button and slowly depress it. Too much force will jiggle the entire photographic system and result in smeared images. Be gentle!

A technique that successfully eliminates jiggle is the "black hat" method, in which an opaque object is placed in front of the lens (such as a flat black piece of cardboard) before the shutter is opened. Then you press the cable release, lock it, and wait for all vibration to cease before removing the cardboard. You don't have to be an octopus to do this: one hand keeps the cardboard in place while the other hand manipulates guiding and cable release functions.

11. Once the shutter is open and the exposure has begun, note the time. An LED-illuminated digital watch is an efficient timepiece for keeping track of exposure lengths, especially if the watch reads out seconds.

12. At the end of the exposure, place your black obscuring device over the lens and release the locking mechanism on the cable release button. You have just taken your first astronomical exposure.

Films for Piggybacking

So far we haven't talked about what films to use. There are several possibilities: gas-hypersensitized Kodak Technical Pan 2415 and Tri-X film for black and white work, hypered or unhypered Konica SR-400 color negative film, or Konica SR 1600 or SR 3200 color print film. Gas-hypersensitized films can be purchased at modest cost through several advertisers in *Deep Sky*, ASTRONOMY, and *Sky & Telescope*.

For the time being, starting exposure times of 5, 10, or 15 minutes can be used to take photos of deep-sky objects with the films above. Keep in mind that these are starting times only. Your actual times are a function of sky conditions, the brightness of the object, the degree of film hypersensitization, and film-processing procedures.

For the beginning astrophotographer there is only one thing left to do that will insure success — go outside and shoot! You'll not only find piggyback astrophotography satisfying but fun too. And nothing compares to your first successful photo. It's only a clear night away!

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CELESTIAL OBJECTS FOR TELEPHOTO LENSES (Northern Hemisphere)

1. The North America Nebula (NGC 7000) in Cygnus.
2. The Gamma Cygni region in Cygnus.
3. The Lagoon and Trifid nebulae (M8 and M20) in Sagittarius.
4. The Andromeda Galaxy (M31).
5. The California Nebula (NGC 1499) in Perseus.
6. The Pleiades (M45) in Taurus.
7. The Orion Nebula (M42).
8. The Horsehead Nebula in Orion.
9. The Beehive Cluster (M44) in Cancer.
10. The Eagle and Omega nebulae (M16 and M17).
11. The Double Cluster (NGC 869 and NGC 884) in Perseus.
12. The Triangulum galaxy (M33).
13. The Rosette Nebula (NGC 2244) in Monoceros.
14. The Virgo cluster of galaxies.
15. The M65 and M66 galaxy field in Leo.
16. The M81 and M82 galaxy field in Ursa Major.
17. The Veil Nebula (NGCs 6960, 6992-5) in Cygnus.
18. The M98, M99, and M100 galaxy field in Coma Berenices.
19. The Coma region.

Treasures of the Unicorn

by Phil Harrington

The stream of the winter Milky Way is dotted with hundreds of exquisite clusters of stars and many delicate interstellar clouds of gas and dust. One of the regions containing plentiful deep-sky objects is located within the large triangular void bordered by Sirius, Betelgeuse, and Procyon. This seemingly empty portion of the seasonal sky is filled by **Monoceros** the Unicorn.

With its brightest star shining at only 4th magnitude, Monoceros commands very little attention from naked-eye skywatchers. Its origins may be traced back to sixteenth century Persia, although the unicorn figure was not widely recognized until the German mathematician Jacob Bartsch included it on his star charts in 1624.

Whatever Monoceros lacks in naked-eye glory, it more than makes up for with its many beautiful telescopic treasures. One of the most attractive open clusters in Monoceros is **NGC 2244**. Highlighted by the yellowish tint of 6th-magnitude 12 Monocerotis, NGC 2244 contains twenty stars brighter than magnitude 11 loosely scattered across 20′. In all about forty suns are members of this group, which lies 750 parsecs away.

A rich-field telescope fitted with a high-quality eyepiece might reveal a faint haze encircling NGC 2244. This dim, irregular glow is the famous **Rosette Nebula**. Most catalogues list it as NGC 2237, but it was originally recorded as NGC numbers 2237, 2238, 2239, and 2246, each number representing one of the Rosette's four brightest portions. Collectively these areas and clouds of fainter nebulosity form a wreathlike nebula over one degree in diameter.

My best view of the Rosette came a few winters ago. Observing from a dark, deserted beach on the North Fork of Long Island, my 4.25-inch f/4 Newtonian displayed a broken, softly glowing ring of light surrounding the stars of NGC 2244. While a nebula filter is recommended to see the Rosette at its best, you may be surprised to find, as I did, that under a dark sky the Rosette is visible without a filter.

Less than two degrees away is **Plaskett's Star**, a 6th-magnitude giant binary system. First investigated in 1922 by astronomer J. S. Plaskett, this system is thought to be the most massive pair of stars yet identified in our Galaxy. This star system consists of two O-type stars orbiting about a common center of mass. The total mass of the system equals about one hundred solar masses, divided about sixty-forty between the two stars. Because it lies at about the same distance, many astronomers believe that Plaskett's Star is a member of the NGC 2237/2244 family.

Northeast of the Rosette Nebula is **NGC 2252.** Unplotted on Wil Tirion's *Sky Atlas 2000.0*, this faint gathering of about thirty stars is difficult to pick out from the surrounding starfield. Use your lowest power when searching for this open cluster: it is loose and spread across 20′. Still farther east is **NGC 2269**. Most observing handbooks and atlases ignore this small open cluster, which holds a dozen stars spread across 4′. The stars' combined 10th-magnitude light is detectable in a 4-inch scope but may require considerable searching.

Surrounding the Rosette Nebula are no fewer than nine Collinder open clusters. None of these is plotted on either *Sky Atlas 2000.0* or the *Atlas of the Heavens*, but these clusters are worth searching for. Farthest west is **Collinder 91**. Twenty stars combine to give this diamond-shaped group a magnitude of 6.4, although Cr 91 is much more difficult to find than its magnitude suggests.

Collinder 96 is a faint, semicircular group of fifteen stars measuring 8′ across. Its magnitude is 7.3 and its brightest member shines at magnitude 8.8.

Collinder 104 and **Collinder 107** practically touch each other in the sky. Positioned to the Rosette's southeast, Cr 104 holds fifteen stars with a combined light equaling magnitude 9.6. Cr 107 is a bright triangular asterism of fifteen stars, highlighted by a 7th-magnitude member. Because this cluster measures over half a degree across, RFTs, finders, and binoculars do the best job at showing its stars.

Collinder 106 is another scattered stellar grouping. Some twenty stars lie within a 40′ diameter and result in a magnitude of 4.6. Again, binoculars and rich-field instruments are best for observing this group.

Little data exists on **Collinder 111**. Listed at 7th magnitude, the few stars that make up this probable asterism are

The rich starfields of Monoceros north and east of Orion's Betelgeuse (lower right) contain deep-sky wonders like the Rosette Nebula (lower left) and various dark nebulae. Photo by Martin C. Germano (50mm f/4 lens, hypered Tech Pan film, 30-minute exposure).

set within 3′. The same can be said of **Collinder 92**. Measuring 11′ across, its weak concentration of stars has a total magnitude of 8.6. The final member of this galactic cluster collection is **Collinder 97**, another poor group. Only fifteen stars are members, so it is certainly difficult to separate the cluster from the background. Only the 7th-magnitude variable AX Monocerotis makes it noteworthy. Some Collinder clusters require much patience and perseverance to successfully observe.

Moving northward, we come to **NGC 2236**, a little known but easy to spot open cluster. Fifty stars of magnitude 11 and fainter populate this small cluster. With my 8-inch f/7 reflector I can resolve a few individual points of light embedded in a circular glow of unresolved haze.

Just west of 4th-magnitude 13 Monocerotis is **IC 448**, a very faint reflection nebula. This object is only one of many small clouds of gas located in Monoceros. The overpowering light from 13 Mon, the same light that illuminates it, renders IC 448 nearly impossible to see. By placing an occulting disk over the star, you may see the faint light of the 15′ by 10′ nebulosity. *Deep Sky* will publish readers' reports of any successful sightings of this object. Be sure to include comments about any special equipment or techniques you used in spotting IC 448.

Less than a degree northeast is 6th-magnitude **14 Monocerotis**. When viewed through 3-inch and larger instruments, the binary nature of this star system becomes apparent. The magnitude 6.5 primary star is orbited by a magnitude 10.7 at p.a. 209°. This pearly white pair is catalogued as Σ938 in Otto Struve's famous catalogue of visual binaries, as well as ADS 5211 in R. G. Aitken's *New General Catalogue of Double Stars*.

NGC 2254 lies just east of 14 Monocerotis. Omitted from both the *Sky Atlas 2000.0* and the *Atlas of the Heavens*, this cluster nonetheless holds fifty magnitude 12 and fainter stars. With a moderate central concentration the cluster is easily visible against the starry backdrop.

Now move a degree due north to encounter the open cluster **NGC 2251**. Despite its implied smallness on the *Sky Atlas 2000.0*, this group impressed me as a fairly large collection of stars from magnitudes 8 to 11. There is a noticeable east-to-west gap in the cluster, which gives the impression of two separate halves.

Trumpler 5 is a rich but faint collection of about 150 stars. Though not well known, this cluster may be found about one degree north of NGC 2251. Trumpler 5 shines at 11th magnitude, and it may prove difficult to view with small telescopes. Even if you are lucky enough to glimpse this group, don't expect to resolve any individual stars. The brightest dimly glow at 17th magnitude!

Moving eastward, we arrive in the vicinity of the strange object called NGC 2261. This object is better known as **Hubble's Variable Nebula** and surrounds the variable star R Monocerotis. Like M78 in neighboring Orion, the shape will remind you of a comet with a broad "tail" extending to the north. Because of the object's high intrinsic brightness, most instruments reveal it easily. (I have no trouble seeing it in a pair of 11x80 binoculars.) Small instruments are quite capable of revealing some structure within NGC 2261. Try high powers for the best view if conditions permit.

In 1916 Edwin Hubble demonstrated that NGC 2261 is variable in both size and magnitude. This effect is apparently caused by dark, obscuring clouds close to the illuminating star. The clouds cause both lighting and shadows to change sporadically, which give the illusion of a changing nebula. A similar effect has been observed in NGC 1555 in Taurus and NGC 6729 in Corona Australis.

R Monocerotis itself is an irregular variable star. Tentatively classified as an RW Aurigae type nebular variable, this unusual star typically shines at 10th magnitude, although it has been recorded as faint as magnitude 13.8. Because of the brightness of the surrounding nebulosity, R Monocerotis is a difficult star to study and observe.

NGC 2264 is a large, bright open cluster easily visible in finder scopes and binoculars. At a glance NGC 2264 appears to be a large, scattered collection of about twenty stars. When viewed with south up, its shape resembles a Christmas tree measuring about half a degree long. Therefore, once again low power is needed to see the entire cluster in a single field of view. The brightest member of the NGC 2264 family is **S Monocerotis**. Also shown as 15 Monocerotis, this blue-white inferno fluctuates only slightly between magnitudes 4.62 and 4.67.

Careful inspection, especially with the aid of a nebula filter, will show the entire NGC 2264 region embedded in faint, cloudy wisps. Extending southward from the Christmas tree's tip is the famous **Cone Nebula**. We have all seen photographs of this splendid sight, which appears almost like an erupting volcano of light, but few can claim to have spotted it visually. Once again we welcome your observations and photographs.

NGC 2259 is located about a degree northwest of NGC 2264, superimposed in front of a portion of the same large patch of nebulosity to which the Cone belongs. About two dozen stars pool their light to make a 4.5′-diameter patch of 11-th magnitude. Telescopes of 10-inch or larger aperture begin to resolve separate points of light. This cluster may be easily passed over, so take your time when searching.

No fewer than five small nebulae lie immediately to the west of the Cone Nebula complex. These include **NGC 2245, NGC 2247, IC 446, IC 2167**, and **IC 2169**. All are exceedingly faint and visible only in large backyard telescopes equipped with premium eyepieces and nebula filters.

Perhaps if you are able to make out NGC 2245 and NGC 2247, you might notice the absence of stars in between them. This "hole" is formed by dark nebulae **Barnard 37** and **Barnard 39**. Because these objects together measure 180′ by 40′ in apparent size, an RFT might be your best bet for detecting them. In general, dark nebulae are difficult to discern from the stellar background.

A group of seven small nebulae lies in southwestern Monoceros about 5° away from Saiph in Orion. **NGC 2170** is the brightest member of this collection. It appears as a shapeless glow surrounding an 11th-magnitude star. **NGC 2185** is only slightly fainter. Look for its dim shimmer encompassing a triangle of inconspicuous stars. I was only able to suspect the existence of **NGC 2183**, which I found just slightly east of NGC 2185. The extremely faint light from NGC 2183 may be glimpsed surrounding a 13th-magnitude star. The last nebula in this region, **NGC 2182**, has always eluded my attempts to view it. Perhaps observers under very dark skies will have better luck.

NGC 2149 is a tiny puff of bright nebulosity set just inside the southwest corner of Monoceros. Backyard instruments reveal a magnitude 12.5 oval smudge measuring only 2′ by 1.5′ across. Observers gazing through 10-inch and larger telescopes should also see the faint illuminating star buried within. Incidentally, the *Atlas of the Heavens* erroneously depicts this object as an unlabeled galaxy.

Aim your telescope just south of the halfway point along an imaginary line between Gamma and Beta Monocerotis. There you will find **NGC 2215**. My notes recall a small, faint open cluster with only about a dozen stars resolved across 10′. The weak glow of fainter, unresolved components can also be seen with averted vision. In all about forty stars form NGC 2215.

Though unplotted on most star

The Rosette Nebula is a great example of an emission region. Inside its delicate, wreathlike nebulosity lies the bright cluster NGC 2244. Can you see the nebulosity with a 6-inch or 8-inch telescope? Photo by Mace Hooley (8-inch f/4.5 scope, hypered Tech Pan, 12-minute exposure).

Deep-Sky Objects in Monoceros

Object	Type	R.A. (2000)	Dec.	Mag.	Mag.★	Size	Distance	Diameter	H
NGC 2149	□R	6h 03.5m	−9°44′	—	9.3	3′ x 2′	—	—	—
NGC 2170	□R	6h 07.5m	−6°24′	—	9.5	2′ x 2′	—	—	—
NGC 2182	□R	6h 09.5m	−6°20′	—	9.0	3′ x 3′	—	—	—
NGC 2183	□R	6h 10.8m	−6°13′	—	13	1′ x 1′	—	—	—
NGC 2185	□R	6h 11.1m	−6°13′	—	12	3′ x 3′	—	—	—
NGC 2215	⊙	6h 21.0m	−7°17′	8.4	10.5	11′	1.0 kpc	3 pc	—
Cr 91	⊙	6h 21.7m	+2°22′	6.4p	—	17′	—	—	—
Cr 92	⊙	6h 22.9m	+5°07′	8.6p	—	11′	—	—	—
Dolidze 22	⊙	6h 23.3m	+4°39′	—	—	18′	—	—	—
NGC 2232	⊙	6h 26.6m	−4°45′	3.9	5.0	30′	0.4 kpc	3.5 pc	—
NGC 2236	⊙	6h 29.7m	+6°50′	8.5	11.0	7′	3.4 kpc	7 pc	—
Cr 96	⊙	6h 3.03m	+2°52′	7.3	8.8	8′	1.1 kpc	2.5 pc	—
Cr 95	⊙	6h 30.5m	+9°56′	—	—	19′	—	—	—
NGC 2239	⊙	6h 31.0m	+4°57′	—	—	16′	—	—	—
IC 446	□R	6h 31.0m	+10°27′	—	10.5	5′ x 4′	—	—	—
IC 2169	□R	6h 31.2m	+9°54′	—	—	30′ x 25′	—	—	—
Cr 97	⊙	6h 31.3m	+5°55′	5.4p	—	21′	—	—	—
NGC 2237-9, 46	□E	6h 32.3m	+5°03′	—	—	80′ x 60′	1.7 kpc	40 pc	—
NGC 2244	⊙	6h 32.4m	+4°52′	4.8	5.8	24′	1.7 kpc	12 pc	—
IC 448	□R	6h 32.7m	+7°19′	—	4.5	15′ x 10′	—	—	—
NGC 2245	□R	6h 32.7m	+10°10′	—	10.8	5′ x 3′	—	—	—
NGC 2250	⊙	6h 32.8m	−5°02′	8.9p	12p	8′	—	—	—
Barnard 37-9	□D	6h 32.8m	+10°38′	—	—	180′ x 40′	—	—	—
NGC 2247	□R	6h 33.2m	+10°20′	—	8.7	4′ x 3′	—	—	—
HGC 2251	⊙	6h 34.7m	+8°22′	7.3	9.1	10′	1.6 kpc	4.5 pc	—
NGC 2252	⊙	6h 35.0m	+5°23′	7.7p	9p	20′	—	—	—
NGC 2254	⊙	6h 3.60m	+7°40′	9.7	11.9	4.0′	2.2 kpc	2.5 pc	—
Cr 104	⊙	6h 36.5m	+4°49′	9.6	—	22′	—	—	—
Basel 7	⊙	6h 36.6m	+8°21′	8.9	10.4	—	—	—	—
Trumpler 5	⊙	6h 36.7m	+9°26′	10.9p	17p	8′	2.4 kpc	5.5 pc	—
NGC 2260	⊙	6h 36.8m	−1°27′	—	—	20′	—	—	—
Cr 106	⊙	6h 37.1m	+5°57′	4.6p	—	45′	—	—	—
Cr 107	⊙	6h 37.7m	+4°44′	5.1	7.1	35′	1.7 kpc	17.3 pc	—
Sh 2-282	□E	6h 38.0m	+1°31′	—	6.2	40′ x 15′	—	—	—
NGC 2262	⊙	6h 38.4m	+1°11′	11.3p	—	3.5′	—	—	—
NGC 2259	⊙	6h 38.6m	+10°53′	10.8	14p	4.5′	—	—	—
Cr 111	⊙	6h 38.7m	+6°54′	7.0p	—	3.2′	—	—	—
NGC 2261	□ER	6h 39.2m	+8°44′	—	10.0v	2′ x 1′	—	—	—
NGC 2264	□E	6h 40.9m	+9°54′	—	4.7	60′ x 30′	0.8 kpc	13 pc	—
NGC 2264	⊙	6h 41.1m	+9°53′	3.9	5p	20′	0.8 kpc	4.5 pc	—
Dolidze 23	⊙	6h 43.2m	+0°00′	—	—	12′	—	—	—
NGC 2269	⊙	6h 43.9m	+4°34′	10.0:	11.6	4′	1.4 kpc	1.6 pc	—
Dolidze 24	⊙	6h 44.2m	+1°36′	—	—	18′	—	—	—
Dolidze 25	⊙	6h 45.1m	+0°18′	7.6	8.9	24′	5.2 kpc	36 pc	—
Cr 115	⊙	6h 46.5m	+1°46′	9.2p	—	7′	—	—	—
NGC 2282	□R	6h 46.9m	+1°19′	—	9.3	3′ x 3′	—	—	—
NGC 2286	⊙	6h 47.6m	−3°10′	7.5	9.7	15′	1.3 kpc	5.7 pc	—
Bochum 2	⊙	6h 48.9m	+0°23′	9.7	10.9	—	—	—	—
NGC 2301	⊙	6h 51.8m	+0°28′	6.0	8.0	12′	0.8 kpc	3 pc	—
NGC 2302	⊙	6h 51.9m	−7°04′	8.9	10.2	25′	1.1 kpc	0.8 pc	—
Biur 10	⊙	6h 52.2m	+2°56′	10.4:	10.7	4.0′	5.0 kpc	5.8 pc	—
NGC 2306	⊙	6h 53.4m	−7°19′	—	—	20′	—	—	—
NGC 2309	⊙	6h 56.2m	−7°12′	10.5p	13p	3′	—	—	—
NGC 2311	⊙	6h 57.8m	−4°35′	9.6p	12p	7′	—	—	—
Biur 8	⊙	6h 58.1m	+6°26′	—	14p	6′	9.0 kpc	16 pc	—
NGC 2316	□ER	6h 59.7m	−7°46′	—	—	4′ x 3′	—	—	—
M50 (NGC 2323)	⊙	7h 03.2m	−8°20′	5.9	7.9	16′	0.9 kpc	4.2 pc	—
Bochum 3	⊙	7h 03.4m	−5°04′	9.9	11.2	—	—	—	—
NGC 2324	⊙	7h 04.2m	+1°03′	8.4	10.4	8′	2.9 kpc	6.7 pc	—
Gum 1	□ER	7h 04.3m	−10°28′	—	7.0	20′ x 20′	—	—	—
IC 2177	□	7h 05.1m	−10°42′	—	6.2	120′ x 40′	—	—	—
NGC 2343	⊙	7h 06.6m	−10°05′	7.2	9.5	12′	1.0 kpc	3.5 pc	—
Cr 465	⊙	7h 07.2m	−10°37′	10.1p	—	9′	—	—	—
Cr 466	⊙	7h 07.3m	−10°49′	11.1p	—	4′	—	—	—
NGC 2343	⊙	7h 08.3m	−10°39′	6.7	8.4	7′	1.0 kpc	2.0 pc	—
IC 466	□ER	7h 08.6m	−4°19′	—	—	1′ x 1′	—	—	—
NGC 2346	■	7h 09.4m	−0°48′	—	11.2v	55″	1.2 kpc	0.3 pc	—
NGC 2353	⊙	7h 14.6m	−10°18′	7.1	9.2	20′	1.1 kpc	6.4 pc	—
Sh 2-294	□E	7h 16.6m	−9°26′	—	—	8′ x 7′	—	—	—
NGC 2368	⊙	7h 21.0m	−10°23′	11.8p	—	5′	—	—	—
NGC 2377	§	7h 24.9m	−9°40′	15:p	—	1.8′ x 1.6′	30 Mpc	16 kpc	Sb+:
Melotte 72	⊙	7h 38.4m	−10°41′	10.1p	—	9′	—	—	—
UGC 3964	§B	7h 40.3m	−1°35′	14.5_B	—	3.7′ x 2.8′	17 Mpc	18 kpc	S(B)dm
Berkeley 39	⊙	7h 46.7m	−4°36′	—	16p	12′	—	—	—
NGC 2506	⊙	8h 00.2m	−10°47′	7.6	10.8	7′	2.2 kpc	4.5 pc	—

atlases, **NGC 2232** is easily visible in binoculars and may even be spotted with the unaided eye. The brightest star within the 5th-magnitude object is 10 Monocerotis. Most of its other twenty stars range from magnitudes 8 to 10, and are set in a triangular pattern. With an apparent diameter equal to that of the Full Moon, NGC 2232 is best seen through short focal length instruments.

NGC 2250 is another open cluster that neither the *Atlas of the Heavens* nor the Tirion atlases show. With a magnitude of 8.9, this group is plainly visible in small telescopes. Using a 6-inch telescope, Canadian observer Pat Brennan describes NGC 2250 in the *Webb Society Deep-Sky Observer's Handbook* (volume 2), as "a small, coarse cluster of faint stars . . . elongated east-west and about 5′ x 4′ in size; stands out quite well with averted vision." What is your impression of this group?

Several small open clusters lie near the center of Monoceros. **NGC 2286** is ignored by nearly all deep-sky handbooks. It consists of fifty magnitude 10 and fainter stars set across 15′ and lies 1.3 kiloparsecs away. **NGC 2260** contains an equal number of stars scattered across 20′. Observers using *Norton's Star Atlas* are well aware of its existence, while it is unknown to those using *Atlas of the Heavens* or *Sky Atlas 2000.0*. NGC 2260 is listed as a Class 7 (nonexistent) open cluster by Sulentic and Tifft in the *Revised New General Catalogue*. Most Class 7 clusters actually do exist, but they are overwhelmed by faint stars and therefore unidentifiable on the Palomar *Sky Survey* charts used by Sulentic and Tifft to check objects for the *RNGC*.

Some 4° north of NGC 2260 lies **NGC 2262**. This is a small, condensed collection of thirty-five stars gathered within 3′. The small apparent diameter of this cluster permits using moderately high magnification while observing the entire cluster.

Now move about a degree to the north between two 6th-magnitude stars. You might spot **Collinder 110**. Within this 12′-diameter cluster lie seventy stars of magnitude 10 and fainter. Observers with small telescopes or giant binoculars should be able to make out something of this group.

Southwest of 18 Monocerotis is **NGC 2282**, a small, faint nebula. Look for it surrounding a 10th-magnitude B-type star. And while in the neighborhood you might view **Collinder 115**, located only a degree north. This open cluster holds fifty dim points of light within its diameter of 7′. Together the stars form

Under a dark sky an 8-inch scope may just show you the dark Cone Nebula (bottom), an elusive object south of S Monocerotis (center). The bright stars in this field are members of an open cluster. Photo by Martin C. Germano (8-inch f/5 scope, hypered Tech Pan film, 45-minute exposure).

a 9th-magnitude glow.

Of all the open clusters in the Unicorn, **NGC 2301** is my favorite. This group contains about eighty stars and resembles a bird in flight. Because of this I call NGC 2301 the "Great Bird of the Galaxy." Most of the member stars are clumped together in a triangular pattern with two distinct star chains (wings) extending to the north and south. If you have never seen the Great Bird of the Galaxy, be sure to look for it on the next clear evening.

Another striking array of densely packed stars is **NGC 2324**. About seventy stars, most of which are magnitude 12 or fainter, are cramped into an 8′ area. Together their light equals that of an 8th-magnitude star. Smaller instruments, unable to resolve all of the cluster members, give the group a misty appearance, while 10-inch and larger scopes can resolve all of its stars.

Located just south of the halfway point between the 5th-magnitude stars 19 and 20 Monocerotis is a small interstellar cloud. Little is written about **IC 446**, and I must admit I have never been able to spot it. Small nebulae need exceptionally clear and dry evenings. Only then will these tiny puffs of light reveal themselves.

Now move back toward the west, past 19 Monocerotis, and stop at open cluster **NGC 2311**. Four dozen stars lie within the group's 7′ area. A 6-inch telescope should be able to resolve about half of these stars, though none is brighter than magnitude 12. The remaining suns show as nothing more than a dim glow in this size instrument, though they are clearly visible in larger scopes.

To find the next target, allow the stars to drift across your telescope's eyepiece for four minutes. This will place the bright nebula **NGC 2316** in view. Lying just north of three faint stars, it is visible as a small, slightly oval patch of nebulosity with a very dim star buried within. Using a 16.5-inch telescope, M. J. Thompson of Santa Barbara, California, wrote in the *Webb Society Deep-Sky Observer's Handbook* that this star is actually an equal-component double. Can you resolve it as two separate stars?

About a degree below NGC 2311 is a triangular asterism of about half a dozen 6th- and 7th-magnitude stars. Pass these and continue another half degree southward until you reach another triangle of 8th-magnitude stars. This is **NGC 2306**. These three beacons, relatively speaking, form the boundary of this easy to find Class 7 open cluster. Set within are twenty-seven fainter stars, highlighted by a 12th-magnitude double in the center and a 10th-magnitude binary toward the southern edge. There is some question if this is a true cluster or simply a chance asterism.

Although NGC 2306 is omitted from popular star atlases, both Tirion and Becvar show a pair of clusters a little farther to the south. **NGC 2302** is a collection of thirty magnitude 10 and fainter stars measuring about 2.5′ across. Medium powers give the best views of this tiny group. **NGC 2309** is a somewhat richer but fainter stellar congregation. Telescopes smaller than 6- inches in aperture have a difficult time resolving any individual points of light, because the brightest stars in NGC 2309 are only 13th-magnitude objects. Even moderately large backyard instruments will be unable to fully distinguish the dimmest stars of NGC 2309. Once again the cluster's small size permits inspection with higher magnification.

Take aim about a third of the way along an imaginary line stretching from Sirius to Procyon. That will place you in the immediate vicinity of **M50 (NGC 2323)**, the only member of the Messier catalogue located in Monoceros. Finding 6th-magnitude M50 is a simple task even in 7-power binoculars, and M50 may just be visible to the naked eye on dark evenings. All of this open cluster's eighty members are moderately compressed inside a 16′ diameter with a striking red star prjominently set amidst an ocean of white and blue-white suns. At a distance of about 910 parsecs M50 is thought to measure about 3 parsecs in diameter.

M50 is but one of a trail of open clusters that dot our path toward the southern border of Monoceros. **NGC 2335** is an unspectacular open cluster with thirty-five stars filling its 12′ diameter. Located close by, **NGC 2343** proves a little more interesting. It is readily visible in 7-power binoculars and appears rather intriguing in 11-power glasses. However, as is typical with many open clusters, telescopes quickly dispel much of the appeal. Twenty stars are scattered across its 7′ diameter, though none is brighter than 9th-magnitude. With such rich surroundings it is often difficult to tell where these clusters end. By the way, NGC 2343 is plotted but unlabeled on *Sky Atlas 2000.0*.

Collinder 446 is a difficult target to hit. It appears as a dim glow measuring only 4′ in diameter. Matters are further complicated by the fact its brightest starry members are only 12th-magnitude. While not much to look at, this rarely observed open cluster will make a nice addition to anyone's list of obscure open clusters.

Measuring about 120′ by 40′, **IC 2177** is a long, faint wisp of nebulosity that bridges the Monoceros-Canis Major border. Some references call this the "Eagle Nebula," although that name popularly applies to M16 in Serpens. Has anyone ever seen IC 2177? It might be possible in large RFTs, if a nebula filter and a premium quality eyepiece are used. If you have success in viewing IC 2177, be sure to send along a note telling us about it.

A little farther east is the lone open cluster **NGC 2353**. A 6th-magnitude star lying on the cluster's western edge shines like a diamond compared with the field of 9th- and 10th-magnitude stars. According to the *Catalogue of Star Clusters and Associations*, this cluster, along with NGC 2335 and NGC 2343, belongs to the Canis Major OB1 Association.

Two faint galaxies lie within the Unicorn. **NGC 2377** is positioned close to a pair of 6th-magnitude stars. Catalogued as an Sb spiral, it shows as nothing more than 14th-magnitude fuzz through most amateur telescopes. The second galaxy, **UGC 3964**, also shines at 14th-magnitude. Both require at least a 12-inch scope for detection.

Bright planetary nebulae are noticeably absent from Monoceros. Only **NGC 2346** stands a fair chance of being seen in amateur telescopes. Its disk measures a whopping 55″ in diameter (large by planetary nebula standards), which results in a very low surface brightness. The other planetaries, listed as members of the *Catalogue of Galactic Planetary Nebulae* by L. Perek and L. Kohoutek, all lie below the threshold of backyard telescopes.

Few amateurs take the time to observe **NGC 2368**. This little known open cluster, though plotted on the *Sky Atlas 2000.0*, is omitted from most deep-sky observing guides. Peering through my 8-inch reflector from the light-polluted grounds of Long Island's Vanderbilt Planetarium, I was just able to see this 11th-magnitude object. Only four faint stars were resolved against the amorphous glow. A 17mm Plossl eyepiece yielded the best view under those less than ideal conditions.

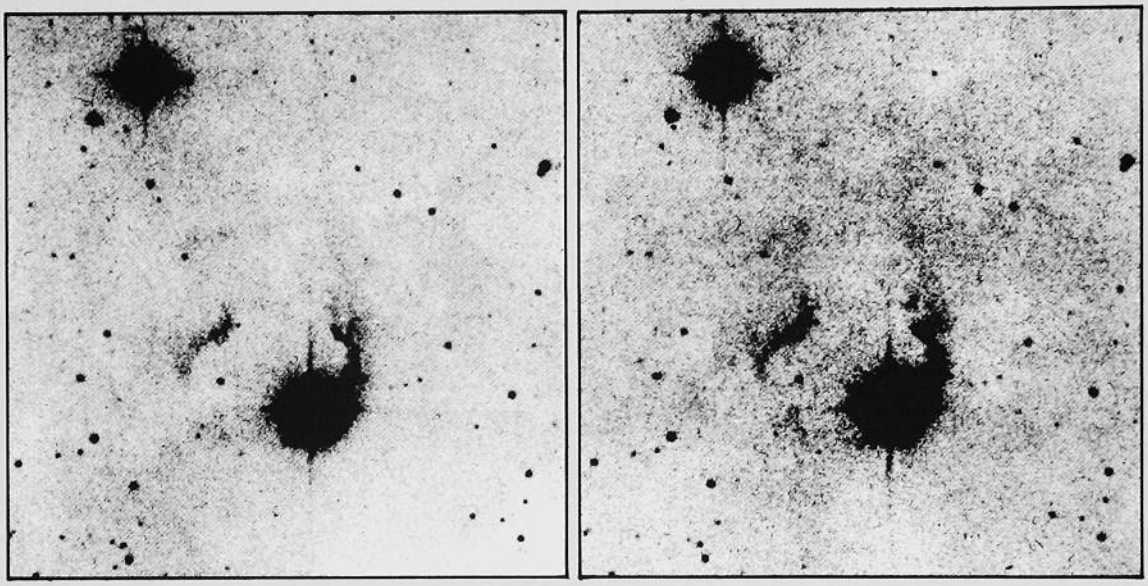
Take aim at 4th-magnitude Alpha (α) Monoceros and move about 2° south-southwest. There lies **Melotte 72**. A 6-inch scope should show some of the forty stars in this rich group at 10th-magnitude. With most stars concentrated toward the center, this cluster's resemblance to a globular is readily apparent.

Lastly, take a look at **NGC 2506**. Positioned in the starless void of eastern Monoceros, this 8th-magnitude open cluster draws very little attention, even though it is easy to spot in finder scopes. About 150 stars belong to this cluster, all lying in a 7′ area. A prominent 10th-magnitude double star highlights the other 11th- and 12th-magnitude cluster stars.

While Monoceros may hold little for naked-eye skygazers, telescopists will be well rewarded for taking the time to wade across its emptiness. If you take the time to visit this region of the sky, some truly wonderful objects await your visit.

Outbursts of FU Orionis Stars

by Ken Croswell



Two photographs of V1057 Cygni, one of a peculiar class of stars called FU Orionis stars. The photo at left includes Hα; the photo at right excludes it. From the fact that these photos, taken at different wavelengths, show comparable densities of nebulosity, astronomers deduced the nebula cannot have an emission spectrum. These photos were taken in 1971 by Eugene A. Harlan and appeared in the* Astrophysical Journal *for 1 November 1977.

In late 1936 a 16th-magnitude star erupted in Orion; by early the next year it had attained 10th magnitude. That star still shines at 10th magnitude today. Astronomers christened the mysterious object FU Orionis. Since its outburst, only four other stars have erupted in a similar manner. Despite their small number, FU Orionis stars confront scientists with great mysteries. Because all five stars are contracting to the main sequence, FU Ori eruptions may help us to understand the lives of very young stars.

FU Orionis lies in northern Orion near the O8 star Lambda (λ) Orionis. The intense ultraviolet radiation from Lambda Orionis has ionized the hydrogen surrounding it, forming a huge HII region centered on Lambda Orionis and extending 25 parsecs in all directions from the star. On the eastern edge of this HII region is the dark nebula Barnard 35, which lies near many young T Tauri stars. Within this dark nebula lies FU Orionis.

Although FU Orionis erupted in 1936, sky patrol plates reveal that the star varied between photographic magnitudes 15.3 and 16.4 before its eruption. FU Orionis took about four months to reach maximum brightness; shortly after its outburst the star lit up a nearby part of its nebula.

The puzzling star remained unique until 1969, when a star embedded in the "East Texas" region of the North America Nebula jumped from 16th to 10th magnitude. The star, V1057 Cygni, attained maximum luminosity in mid-1970, when its spectrum was that of an A-type supergiant. Since its outburst, V1057 Cygni has cooled and now is spectral type F–G. The star faded by two magnitudes in only six years and now lies three magnitudes below peak brightness. As luck would have it, Lick astronomer George Herbig made a spectrogram of V1057 Cygni in 1957, before the star had erupted. Although it is a low-resolution spectrogram, it indicates V1057 Cygni was a T Tauri star prior to its outburst.

In 1975 another star in Cygnus, V1515 Cygni, came to attention. This star lies near the nebula NGC 6914 and rose from 17th to 13th magnitude. But V1515 Cygni took several decades to brighten, which makes it the slowest of the FU Orionis stars. A few years later, yet another star in Cygnus entered the FU Orionis class: Elias 1-12. Although astronomers first noticed the star in 1977, it actually erupted more than a decade earlier. Elias 1-12 is near the young star cluster IC 5146. The fifth and final FU Orionis star erupted around 1980 and was discovered in 1983. It lies in Norma on the northeastern tip of Herbig-Haro object 57. (Herbig-Haro objects are nebulous knots that lie in regions of star formation.)

Although each FU Orionis star has increased in brightness by four to six magnitudes, rise times vary. FU Orionis itself took only a few months to attain maximum luminosity, whereas V1515 Cygni required several decades.

Decay times also vary. While FU Orionis is still going strong fifty years after its eruption, V1057 Cygni is much dimmer today than it was in 1970.

All five FU Orionis stars have spectral types of F–G. All five stars are also young: all lie near nebulosity, all lie near other young stars, and one — V1057 Cygni — was definitely a T Tauri star prior to outburst. In fact, all five stars were probably T Tauri stars prior to their entrance into the FU Orionis class; many if not most T Tauri stars may go through the FU Orionis stage. Herbig believes a given star erupts several times during its life as a T Tauri star. Our Sun probably went through the FU Orionis stage when it was young with possibly profound consequences on the developing solar nebula.

The FU Orionis stars exhibit blue-shifted absorption in the red Hα λ6563 line and the orange Na I D $\lambda\lambda$5890, 5896 lines. The star ejects material that heads toward us and absorbs light from the star behind it; therefore, the blue-shifted absorption indicates the FU Orionis stars lose mass.

Actually *all* stars lose mass to some extent. Our Sun, for example, loses mass at the relatively small rate of about 10^{-14} $M_\odot$ per year in the form of solar wind. Mass loss is especially common among young stars: T Tauri stars have much larger mass loss rates of 10^{-8} to 10^{-9} $M_\odot$ per year. Since they have undergone dramatic eruptions, FU Orionis stars might have even greater mass loss rates, perhaps enough to affect the dynamics of interstellar clouds and produce Herbig-Haro objects as well.

Recently Lee Hartmann and I took spectra of FU Orionis, V1057 Cygni, and V1515 Cygni to estimate the mass loss rates of these stars. By matching the observed Hα and Na I D lines with model calculations, we conclude that FU Orionis stars are losing mass at a rate of 10^{-5} to 10^{-6} $M_\odot$ per year — one hundred to one thousand times greater than the mass loss rates of T Tauri stars. Moreover, of the three stars we studied, V1515 Cygni has the greatest mass loss rate, FU Orionis has the second greatest, and V1057 Cygni the weakest. We believe these very large mass loss rates point to FU Orionis stars as the source of Herbig-Haro objects, especially in light of the recent discovery of an FU Orionis star near HH 57.

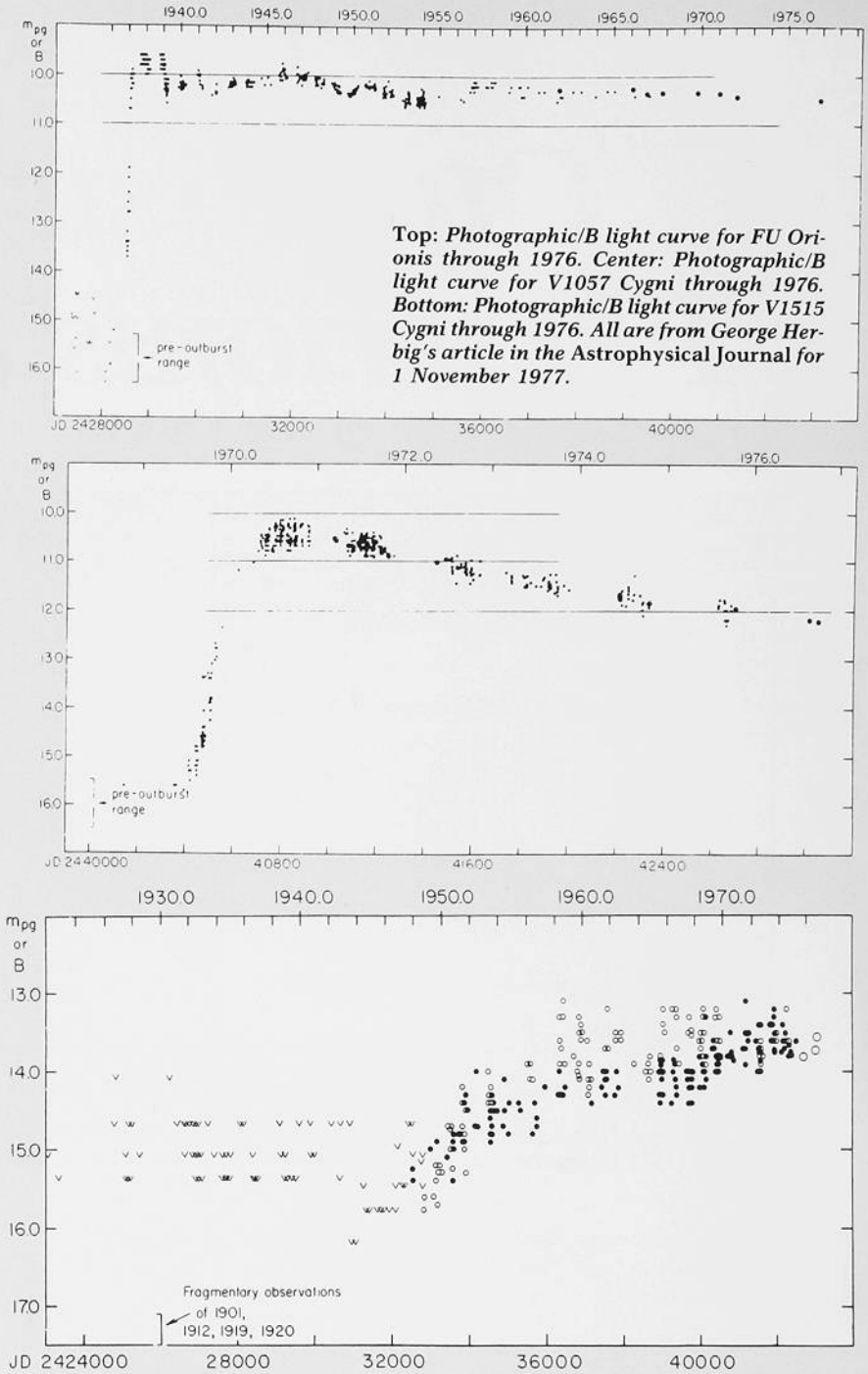
A star loses mass in all directions, so we should also observe material heading away from us, material that produces redshifted emission. Yet the FU Orionis stars exhibit only weak redshifted emission, which suggests that a disk surrounds each star and occults emission from receding material. Such FU Orionis disks are probably solar systems in the making.

What causes FU Orionis stars to erupt? Perhaps the star breaks through the cocoon of gas and dust surrounding it, which makes it look much brighter to observers on Earth. But this idea cannot explain the recurrence of FU Orionis eruptions or the fading of V1057 Cygni. Another possibility is the infall of a Jupiter-sized planet into the star, which would release enough gravitational potential energy to produce the observed luminosity increase but would do so much faster than the rise times allow.

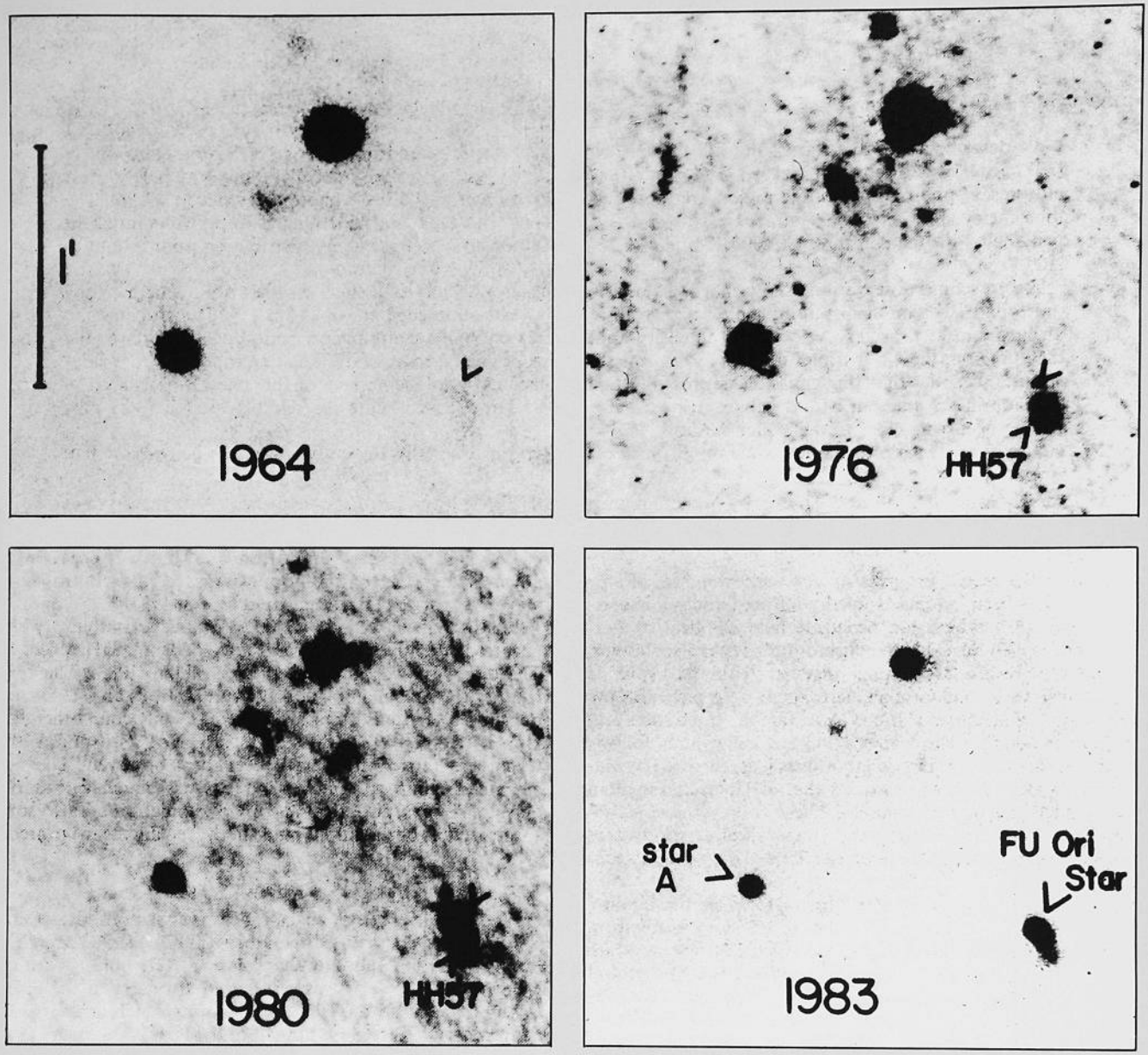
A more likely possibility is that the FU Orionis outburst is a structural adjustment of a star as it contracts to the main sequence. Another possibility invokes runaway nuclear reactions. The most recent hypothesis, proposed by Lee Hartmann and Scott Kenyon, suggests the FU Orionis disks are similar to the accretion disks that exist around dwarf novae and that the disks power the eruptions.

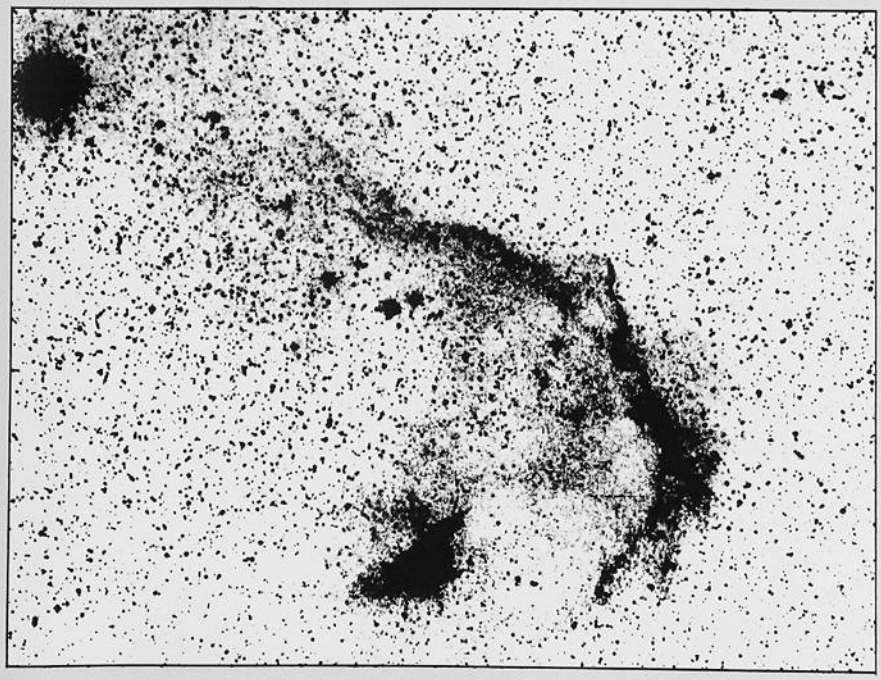
FU Orionis eruptions are an important aspect of early stellar evolution. But many questions remain: Do all T Tauri stars go through the FU Orionis stage? If not, which ones do? How long does the FU Orionis stage last? How often does it occur in a given star? And, finally, what causes these outbursts?

We may never answer these questions if we do not discover more FU Orionis stars. We know more about these stars today than we did when FU Orionis was a unique object, but to advance our understanding of these important stars, we need more of them



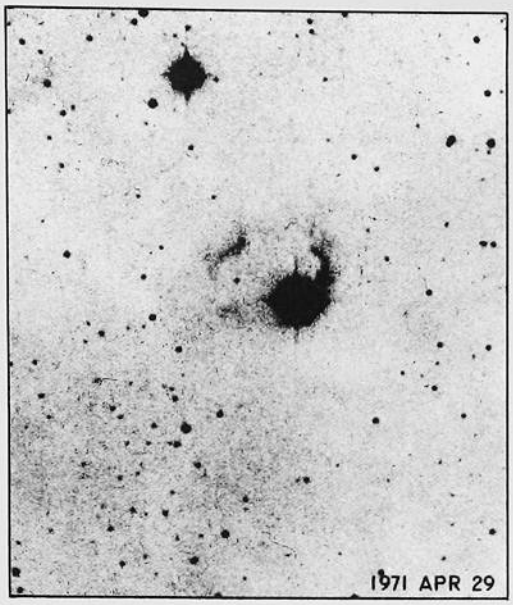
Top: ***Photographic/B light curve for FU Orionis through 1976. Center: Photographic/B light curve for V1057 Cygni through 1976. Bottom: Photographic/B light curve for V1515 Cygni through 1976. All are from George Herbig's article in the*** **Astrophysical Journal** ***for 1 November 1977.***





Above: *These four sections of sky surveys from Palomar Observatory, the European Southern Observatory, and Cerro Tololo Interamerican Observatory show the mysterious behavior of the HH 57 star. From John A. Graham and Jay A. Frogel's* Astrophysical Journal *paper published on 1 February 1985.*

Left: *The region of B35 from the red exposure of the Palomar Observatory* Sky Survey. *FU Orionis is the overexposed nebulous star near bottom center. Palomar Observatory photograph.*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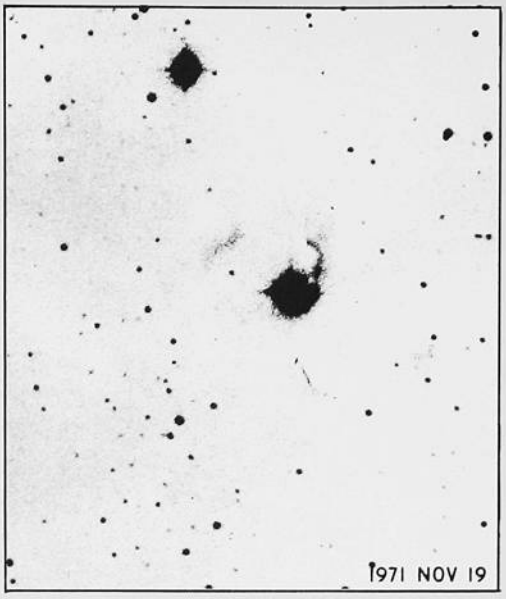
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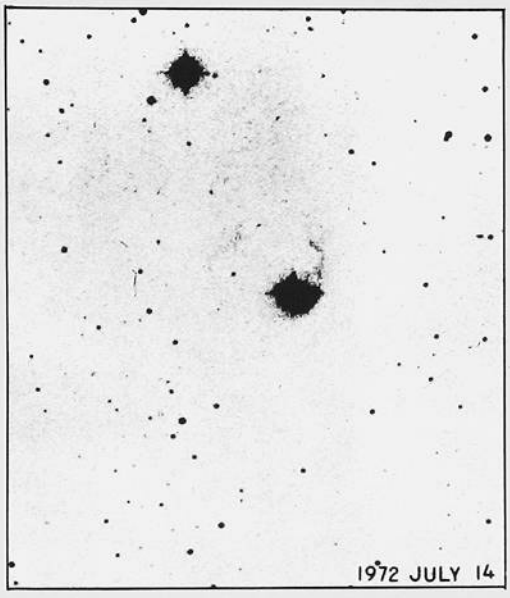
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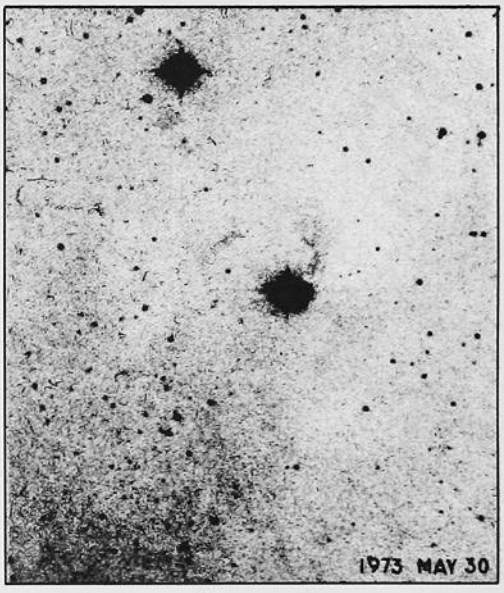
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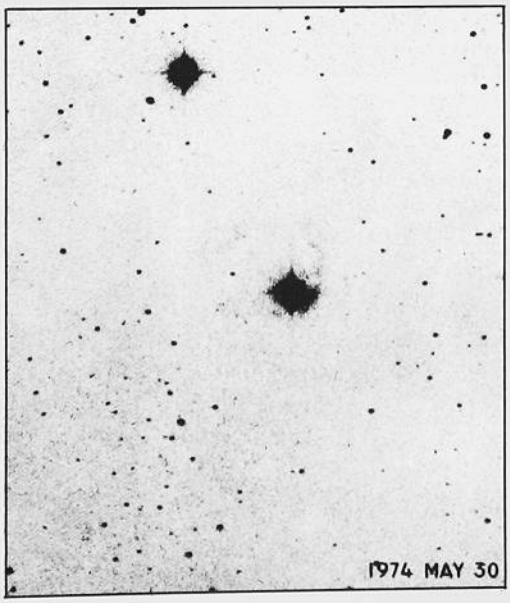
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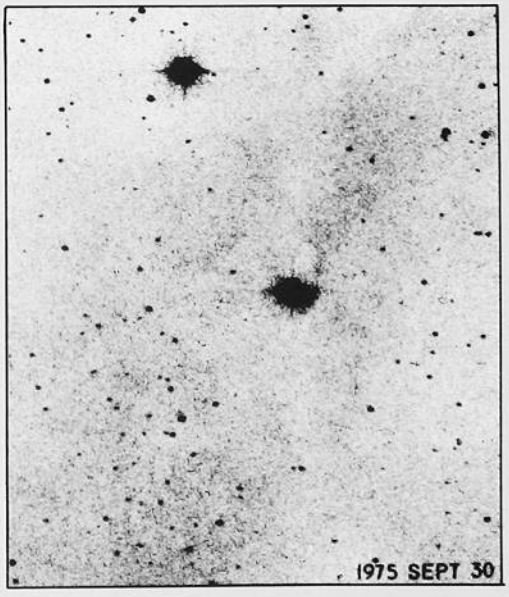
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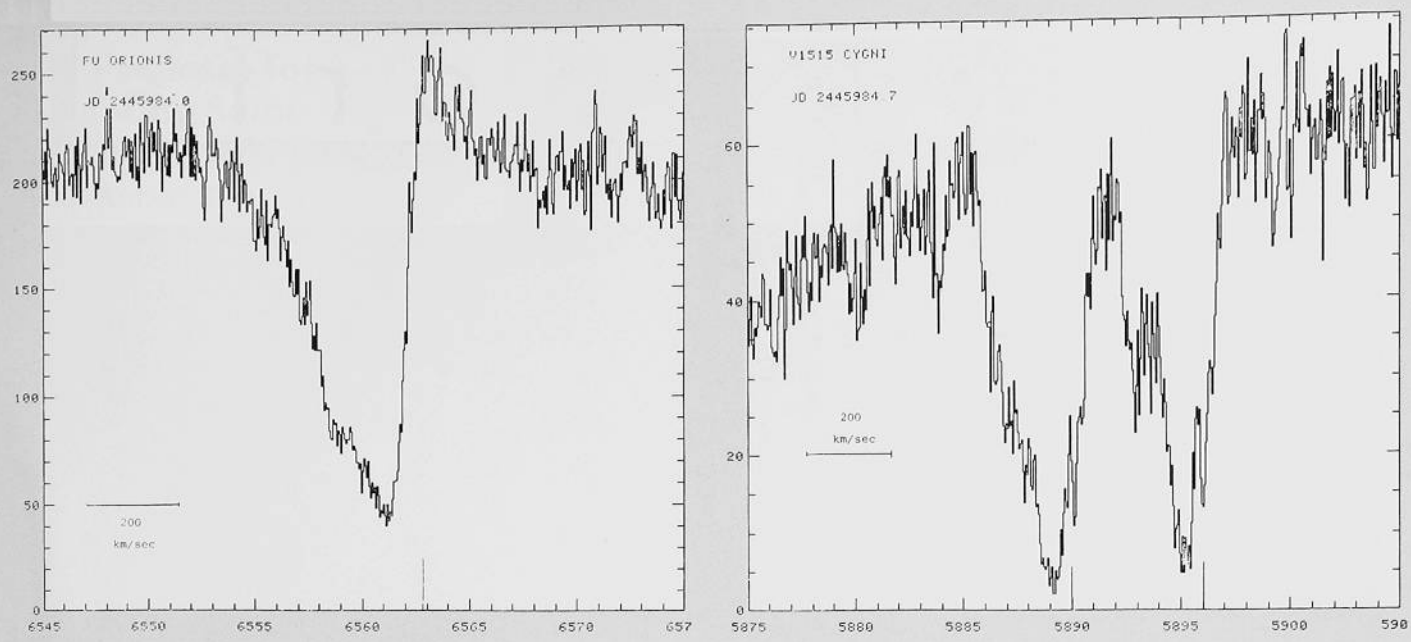

Above left: ***An Hα line profile of FU Orionis. Rest wavelength is marked by the vertical line. The blueshifted absorption indicates the star is losing mass. From Croswell, Hartmann, and Avrett (1986).***

Above right: ***Na I D line profiles of V1515 Cygni. The rest wavelengths are marked by vertical lines. Again, the blueshifted absorption indicates the star is losing mass. From Croswell, Hartmann, and Avrett (1986).***

Opposite page: ***Photographs of the nebulosity surrounding V1057 in Cygnus, showing the slow fading of both nebula and star. These photos were made with the Lick Crossley reflector and are from George Herbig's* Astrophysical Journal *paper published on 1 November 1977.***

to study. Although professional astronomers discovered all five FU Orionis stars, amateur astronomers may succeed in locating such stars in the future.

The task will be quite a challenge, however. Even at maximum luminosity an FU Orionis star will be quite faint: the first three FU Orionis stars peaked between 10th and 13th magnitude. Photography may be useful in the search for more FU Orionis stars; comparing two photographs of the same region of sky may reveal a new FU Orionis star. The more sensitive the plates are to red light, the better: FU Orionis stars lie behind clouds of dust and gas that redden the light of the stars. An FU Orionis star is typically one or two magnitudes brighter at V (yellow) magnitudes than at B (blue) magnitudes. Because an FU Orionis star remains bright for years after its outburst, photographs taken months or even years apart would still be useful. However, professional astronomers will want to study any new FU Orionis star as soon as possible after its eruption, so the period between two successive plates should be kept at less than two months.

Although FU Orionis stars will be faint, we know where they will appear: along the galactic plane. FU Orionis stars are young, and young stars line the great spiral arms of our Galaxy. Regions of the Milky Way that contain stellar nurseries, pre-main-sequence stars, T Tauri stars, HH objects, and HII regions are ideal hunting grounds.

Actually, we can be even more specific. The Sun lies along the inner edge of the Orion spiral arm. We see this arm when we look to the Milky Way winding through Monoceros, Orion, Taurus, Auriga, Perseus, Cassiopeia, Cepheus, Lacerta, and part of Cygnus. It is in these constellations that the nearest — and therefore the brightest — FU Orionis stars will erupt. When we look to Sagittarius and Scorpius, we view the spiral arm that lies interior to ours: the Sagittarius arm. Although the Sagittarius arm also abounds in young objects, it lies 1.3 kiloparsecs away; therefore, any FU Orionis eruption here will be very faint. The most recent FU Orionis star, the one associated with HH 57, did erupt here and peaked at photographic magnitude 18. Therefore, the northern Milky Way provides the best place to look for such stars.

The search for additional FU Orionis stars will not be easy, and we do not know how rewarding it will be. In the last twenty years three FU Orionis stars have erupted, which suggests only one eruption every six or seven years. But for every FU Orionis event observed, many more have undoubtedly escaped our attention.

There surely are other FU Orionis stars about to erupt, and they may finally help us understand this enigmatic stage of stellar evolution: a stage our Sun likely went through, and a stage that may have shaped the solar system we now inhabit.

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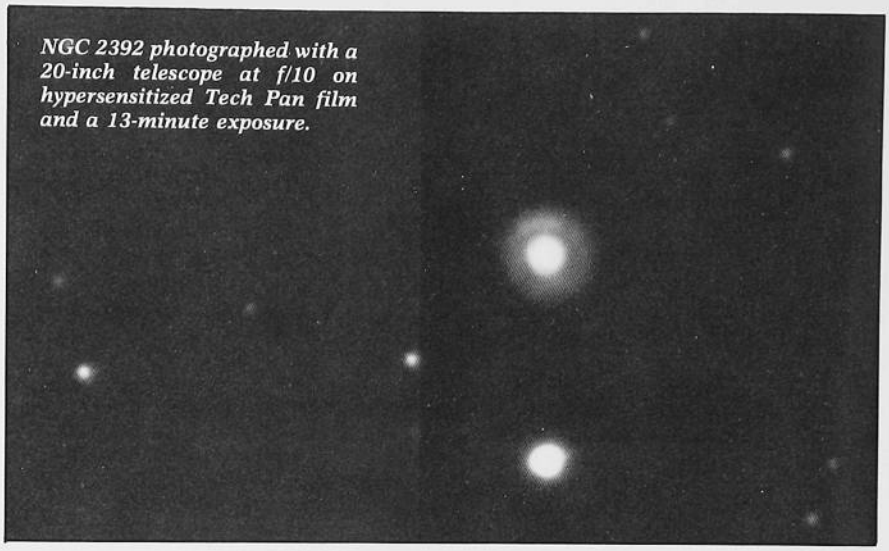
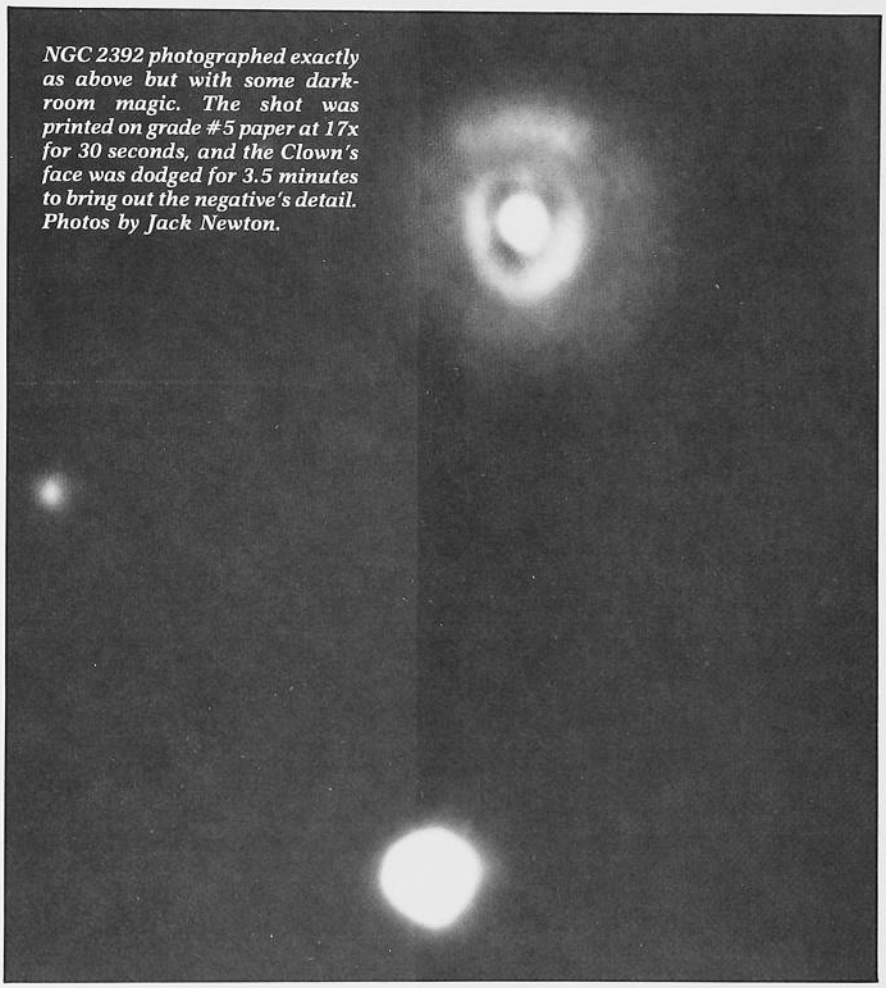
In Search of the Clown

by Jack Newton



NGC 2392 photographed with a 20-inch telescope at f/10 on hypersensitized Tech Pan film and a 13-minute exposure.



NGC 2392 photographed exactly as above but with some darkroom magic. The shot was printed on grade #5 paper at 17x for 30 seconds, and the Clown's face was dodged for 3.5 minutes to bring out the negative's detail. Photos by Jack Newton.

NGC 2392, the Clown Face Nebula, is a lovely deep-sky object. It measures 19″ by 15″, glows at photographic magnitude 9.9, and has a 10th-magnitude central star that is easily visible in small scopes. A stunning red-light photo of the Clown Face Nebula appears in *Burnham's Celestial Handbook*, volume 2, on page 941. This Palomar 5-meter telescope shot reveals very distinct features of what appears to be a face surrounded by hair or fur with eyes, a mouth, and the central star for a nose.

The subtle detail that led to the nickname Clown Face Nebula is quite difficult to view in amateur telescopes, but the attractiveness of this object made me want to photograph as much detail in it as I could. One day I became so worked up about NGC 2392 that, though no one was around to hear, I yelled out, "Wow! This is going to be fun to photograph!"

I made my first photograph of the Clown Face Nebula with a 16-inch f/5 telescope and a cold camera. The fur around the clown's face showed up, but the face itself was completely burned-in. Later I tried photographing NGC 2392 with my 20-inch scope at ambient temperature with a 5-minute exposure, but still no face. Determined, I hypersensitized Kodak Tech Pan film and photographed the object for 10 minutes. No luck: The nebula's center still refused to show detail.

At this point I felt I had to increase the image scale. (While the whole world is telecompressing, I got the urge to tele-expand!) I dismantled a 2x Clave Barlow lens and built a holder that could adjust the Barlow to cause a 2x increase in focal length. Then I timed a star drifting across the short axis of my 35mm cold camera's field. This drift required 150 seconds. Next I adjusted the Barlow so the star would require just 75 seconds to cross the field. The telescope was now operating at f/10 with a 200-inch focal length. I used a magnification of 600x to guide with an off-axis guider and made a series of photographs 4, 6, and 10 minutes long. The guiding had to be precise, and my 15-inch Mathis drive gear proved worthy of the task. The photos reproduced here were made with hypered Tech Pan film and a Lumicon Deep-Sky filter.

The first print shows only faint signs of facial features. However, with 30 seconds of dodging on grade #5 paper, the face I had hoped to record finally showed up.

Originally I had no idea what an enjoyable challenge this object would provide, but the results were gratifying, especially since I was working with a homebuilt camera and telescope.

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A Proposal for Naming Some Deep-Sky Objects

by Robert Reeves

If someone asked you where NGC 1499 and NGC 7000 are in the sky, you might not be able to answer him. But almost certainly you have heard of, and probably know the positions of the California Nebula and the North America Nebula. Popular names give major deep-sky objects a style and personality peculiarly their own and allow us to relate to the objects in human terms. They also take the dryness out of reading multitudes of similar catalogue numbers.

With the recent advances in amateur astrophotography a great number of previously unnoticed faint nebulosities can be recorded with standard equipment and films. These nebulae do not yet have popular names, mainly because they have been beyond the reach of amateur equipment in the past.

In the spirit of a better understanding of the sky I humbly submit the following names for a new group of objects that deserves them.

The Pac-Man Nebula

NGC 281 (epoch 2000.0 position: 0h53m, +56.5°) is a bright, round nebula in Cassiopeia with a pie-shaped section apparently missing. To me, NGC 281 looks like the hungry little man in the world's most popular video game, Pac-Man.

The Valentine Nebula

Cassiopeia also contains two giant, faint nebulae called IC 1805 and IC 1848. The westernmost of these side-by-side objects, IC 1805 (2h32m, +61.5°), resembles a giant heart-shaped valentine. This object, high in the cold February sky, is a deep-sky object dedicated to all astronomical sweethearts.

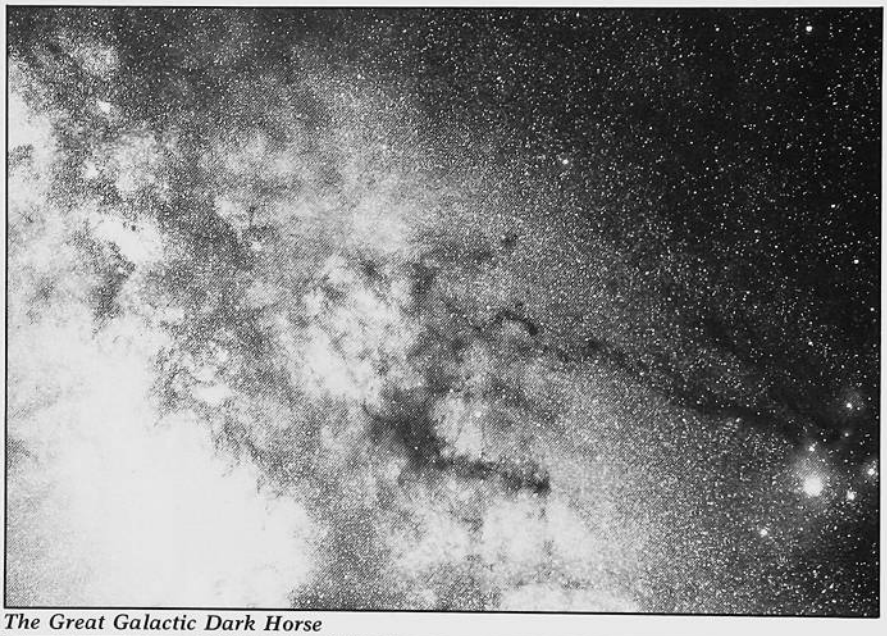
Orion's Brother

Amateur astronomers have made thousands of photographs of the Orion Nebula (5h35m, −5.5°). This great nebula is so bright that only a few minutes of exposure time are needed to capture a beautiful image. However, photographers of the Orion Nebula region who expose for extremely long periods can record a dark region in the southern part of the M42 cloud that resembles the profile of a human face. I call this object Orion's Brother.

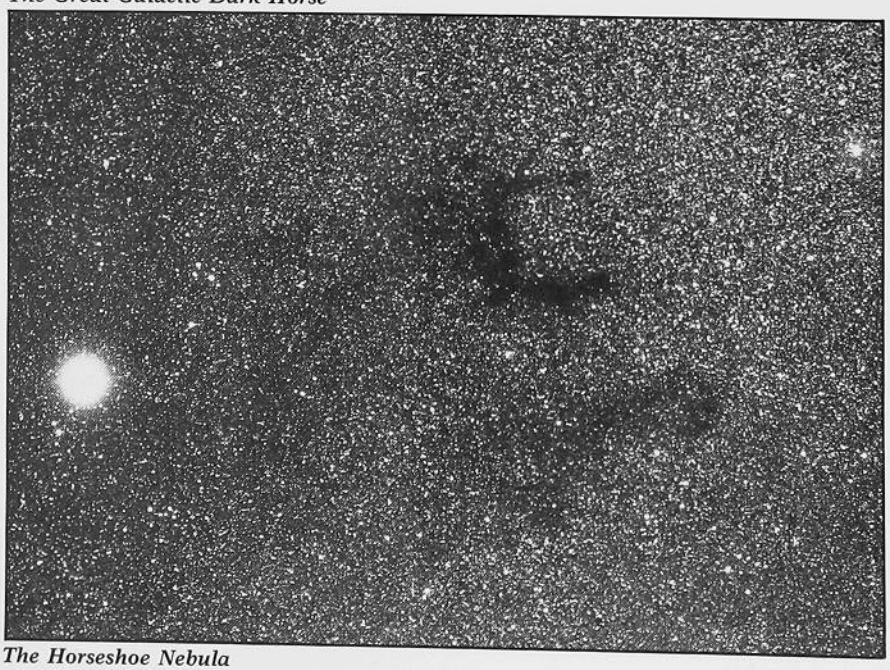
Orion's Dagger

Also in Orion is a feature so obvious I'm surprised it hasn't been named before. The long, tapered nebula IC 434 (5h41m, −2.5°) is well known because it backlights the Horsehead Nebula. IC 434 itself should have a nickname, because it appears like a knife tucked into Orion's belt. Therefore, I call this

The Valentine Nebula

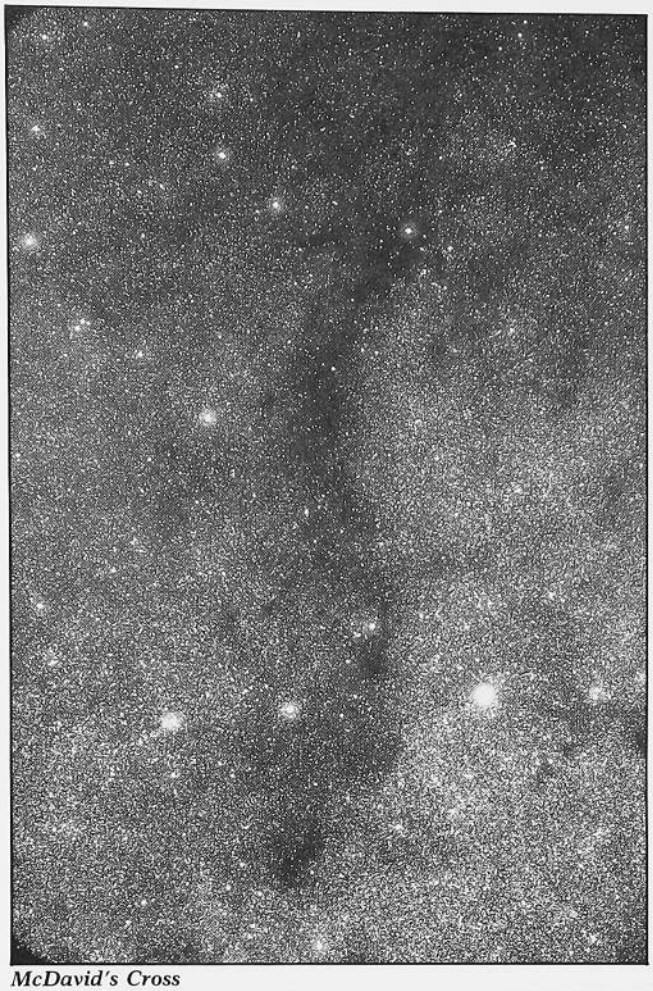


The Great Galactic Dark Horse



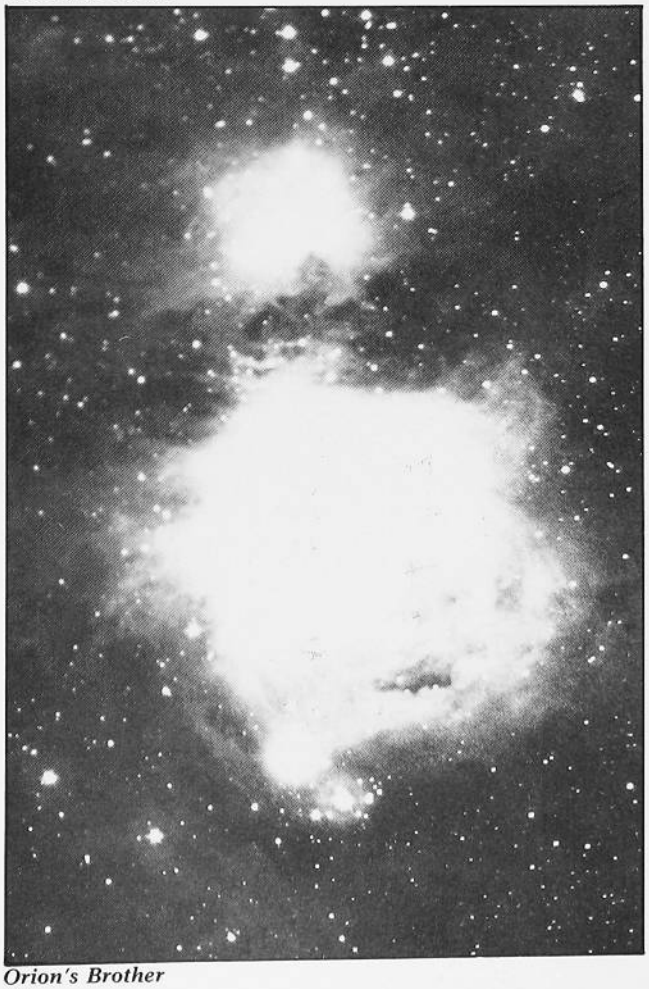
The Horseshoe Nebula

All photographs by Robert Reeves, who used a 300mm lens and hypersensitized Tech Pan film.

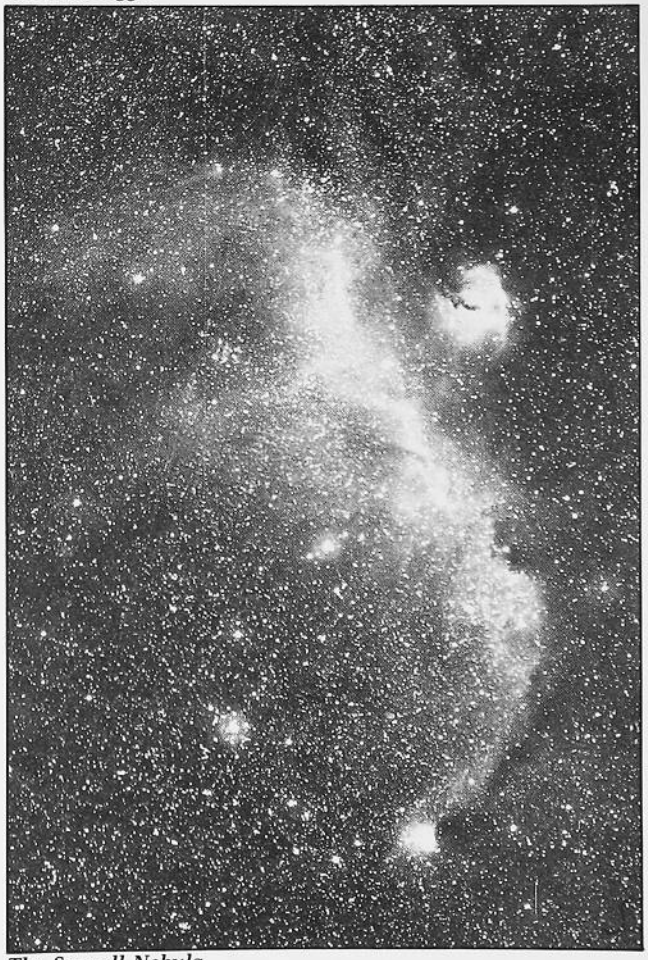


McDavid's Cross

Orion's Dagger

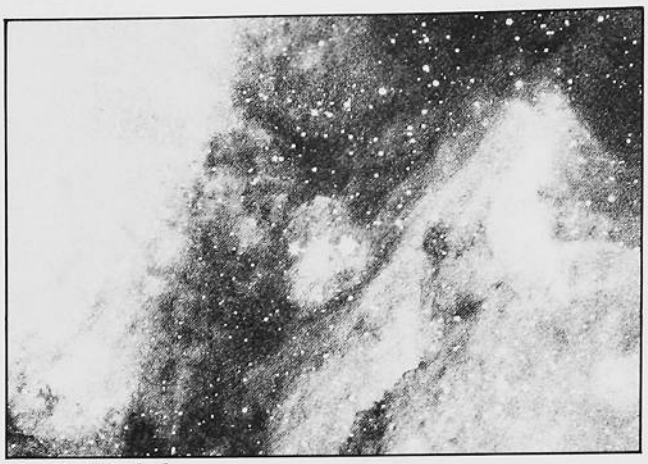


Orion's Brother



The Seagull Nebula

The Pac Man Nebula



The Skull Nebula

The Butterfly Nebula

object Orion's Dagger.

The Seagull Nebula

Lying in the winter sky along the border between Canis Major and Monoceros just south of the cluster M50 is the faint nebula IC 2177 (7h05m, −11°). This nebula is unknown to many amateur astronomers. *Burnham's Celestial Handbook* states that this object is called the Eagle Nebula. However, everyone knows the Eagle Nebula is M16 in Serpens Cauda. The last thing backyard astronomers need is two Eagle Nebulas. To me, M16 looks like an eagle, but IC 2177 doesn't. My imagination sees in IC 2177 the graceful splendor of a seagull gliding on a coastal breeze.

The Great Galactic Dark Horse

Just north of the heart of the summer Milky Way lies an area containing many black dust lanes and interconnected dark nebulae. In this area of southern Ophiuchus and western Serpens Cauda (centered at 17h40m, −10°) is an association of dark nebulae that combine to form the giant outline of a prancing horse. It is fitting this equestrian monument should be called the Great Galactic Dark Horse.

The Butterfly Nebula

Many observers know M6 in Scorpius as the Butterfly Cluster. But I believe the sprawling nebula in Cygnus called IC 1318 (20h25m, +40°) should be called the Butterfly Nebula. The large, dark band of dust in the middle of this object is pinched, which makes the nebula look like a butterfly in flight.

The Skull Nebula

Located in the dark "gulf stream" between the North America Nebula and the Pelican Nebula in Cygnus (20h53m, +44.5°) is a faint, round nebula that shows up only in long-exposure photographs. Embedded in this nebula are two bright stars.

The first time I saw this object I was processing a photograph of the North America Nebula area. As the object slowly materialized on the developing print, it took on the unmistakable appearance of a skull. The two bright stars appeared like eyes. So this little nebula should be called the Skull Nebula.

McDavid's Cross

Winding upward from north of the North America Nebula is a slender S-shaped dark nebula called Cygnus Gaseous Filament 7 (21h05m, +47.5°). This object has been studied extensively at McDonald and Kitt Peak observatories by David McDavid, a friend of mine.

Crossing the southern part of GF-7 is an east-west row of four bright stars. The two central stars in this row are 59 Cygni and 63 Cygni. Coupled with the north-south nebula, these stars form a cross. McDavid has spent a great deal of time investigating this object, so I call it McDavid's Cross.

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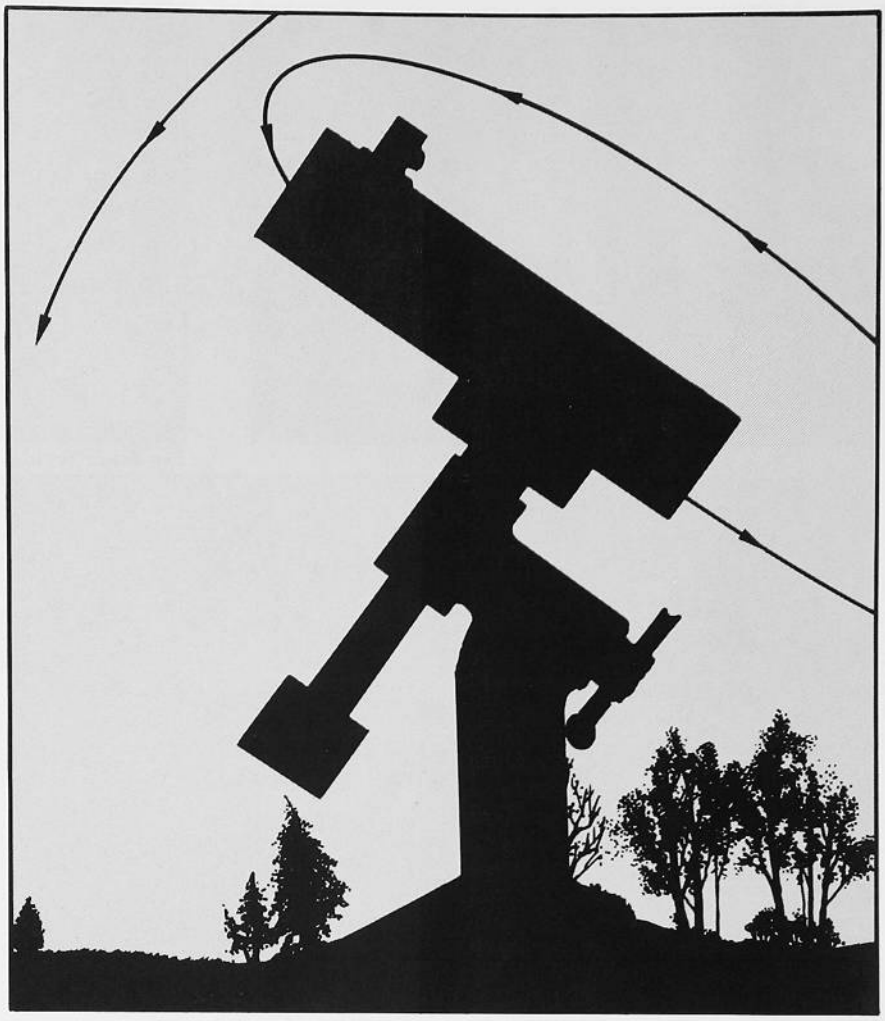
A Simple Method for Locating Deep-Sky Objects

by T. C. Hoffelder



Appreciating the view of a sparkling cluster or the subtle beauty of a galaxy is the main reward for deep-sky enthusiasts. But a big part of the deep-sky hobby is also locating the objects: you have to find 'em before you can view 'em. Unfortunately the lack of a convenient object locating system discourages many would-be deep-sky observers from becoming experienced deep-sky observers. However, the right-angle sweep (RAS), a relatively unsung system of finding objects, utilizes the north-south and east-west motion of an equatorial mount to simplify finding objects.

To explain this method, allow me to take you through an example of how it works. To find M104, the lovely Sombrero Galaxy in Virgo, you need to aim your telescope 5° north and 2.5° east of Delta (δ) Corvi. You can identify Delta Corvi by consulting any basic star chart. To locate M104, first center Delta in an eyepiece that provides a 1° true field. Note that by centering on Delta, your efforts have already shown you a beautiful yellow and pale lilac double star.

After soaking in the double, slowly move the telescope north using only the declination axis toward Polaris. Gauge the distance by following a star on the northernmost edge of the field of view as it moves across the entire diameter to the southern edge of the field. Repeat this step four more times, and you've completed a 5° move northward. Now move the telescope east (a movement of the polar axis only in an eastward direction) two-and-one-half fields by following stars edge to edge.

That's all there is to it. An edge-on galaxy composed of light 40 million years old will now lie near the center of your eyepiece. The time required to do this sweep is less than that required to read these introductory instructions.

The right-angle sweep provides three advantages over other methods of locating objects. It is certainly the most efficient: you point the scope at a star, sweep north or south, and then sweep east or west. The object's position can be located in seconds, which increases the time available for observing. Setting up is not difficult; because sweep distances are generally a few degrees, you need not precisely polar align the telescope. Even if the polar alignment is off by 3°, the object will still be within 15′ of the field center after a 5° sweep.

Another advantage is positive identification. A correctly performed sweep leaves no doubt that the object in the eyepiece is the object sought. This is particularly useful in areas like the Coma-Virgo cloud where the density of objects can cause confusion. In such areas, sweeps can be made from object to object, which saves time and further helps identification.

Right-angle sweeps also help familiarize you with constellations. By forcing you to observe stars and then deep-sky objects lying nearby, you learn a great deal about the placement of objects in constellations. This is a very valuable aid for getting to know the sky.

Calculating sweep distances requires knowing right ascension and declination for the stars and objects in question. If you don't have this information or can't stand the thought of calculating lots of distances, Florida amateur Gerald Shaw offers a list of sweeps for seven hundred objects for $10. (Write him at 2460 Northeast Marian Street, Jensen Beach, FL 33457.) For those interested in crunching the numbers, the declination sweep is the difference between declination values for the star and object (same epoch) in degrees, and the direction of sweep is obvious from the two values.

The right ascension sweep is more involved, because hours and minutes must be converted to degrees. Furthermore, the convergence of right ascension lines toward the celestial pole must be considered. First obtain the difference between star and object in minutes of right ascension. Next divide the difference by four (four minutes of time equal one degree on the celestial equator). Finally, multiply by the cosine of the declination angle of the object, because the cosine function is the closure rate of right ascension lines. Thus, four minutes of right ascension at 60° declination is equal to 30′ true field instead of one degree.

Because a right angle sweep is based on the motions of an equatorial mount, using an equatorial mount is a definite advantage. However, if you really wanted to you could use an altazimuth mount, the north-south and east-west motions can be approximated, especially near the meridian.

The right-angle sweep is recommended for anyone interested in streamlining his observational procedures. It's practical even for inexperienced observers who are usually able to locate specific objects on their first attempts. Whether you're experienced or not, the right-angle sweep can revolutionize the way you observe.

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Observing and Plotting Cataclysmic Variables

by Gerald P. Dyck

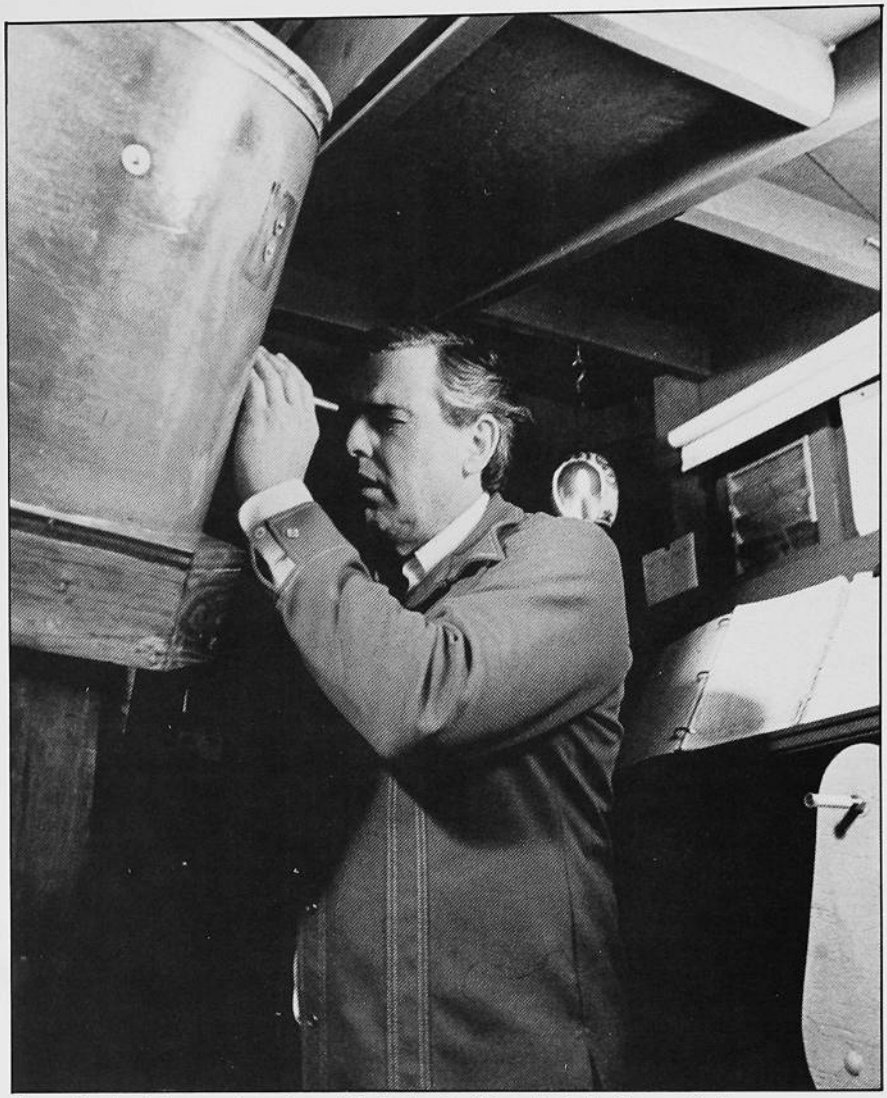
A great deal has appeared in *Deep Sky* concerning variable stars and variable star observing. Because of this and because I am a dedicated variable star observer, I decided to describe my observatory, observing techniques, processing and reporting methods, and the analysis of variable star data I do at home in Massachusetts. I am particularly involved with cataclysmic variables and hope my thoughts may interest others coming into the variable star field.

I call my backyard observatory High Hill Observatory, although it is neither high nor on a hill. It is a small, merry-go-round building located at 418 North High Hill Road in Dartmouth. Built in the summer of 1984, the observatory was designed to provide maximum convenience for variable star work. The 8' by 8' boxlike structure houses a homemade 17.5-inch f/4.5 Dobsonian telescope that sits off-center to provide a working space on the eyepiece side of the instrument. A chart table, an adjustable observing chair, a building control crank, and observing paraphernalia lie nearby and remain in the same spot relative to the observer as the building turns.

The observatory's roof slit and door allow for zenith-to-horizon viewing and the telescope can turn independently from the building. One easy turn of the crank moves the structure 5° in azimuth. When the Moon is absent, the telescope's limiting magnitude in my sky is about 15.0, and it takes only about five minutes to set up and start observing. The observatory is a joy to use, and I've only noticed one drawback in the three years I've used it: on nights of peek-a-boo viewing between clouds it takes a little time to move the scope back and forth between cloudless spots in the sky. But I hear the Multiple Mirror Telescope has the same problem, so I'm not too concerned!

After several years of randomly observing variable stars, I've decided to concentrate on cataclysmic stars for three reasons. First, I am excited by their unpredictability. Second, I was captivated by seeing a cataclysmic star appear where no star had previously been visible. And third, cataclysmic stars can be observed on any clear night, which allows a high density of data to accumulate.

I began with SS Cygni and now monitor eighty cataclysmic stars. To minimize search time and remember the positions of stars, I use a mnemonic device, a silly little saying that outlines



Gerry Dyck at home observing. All photos in this article by Gerry Dyck.

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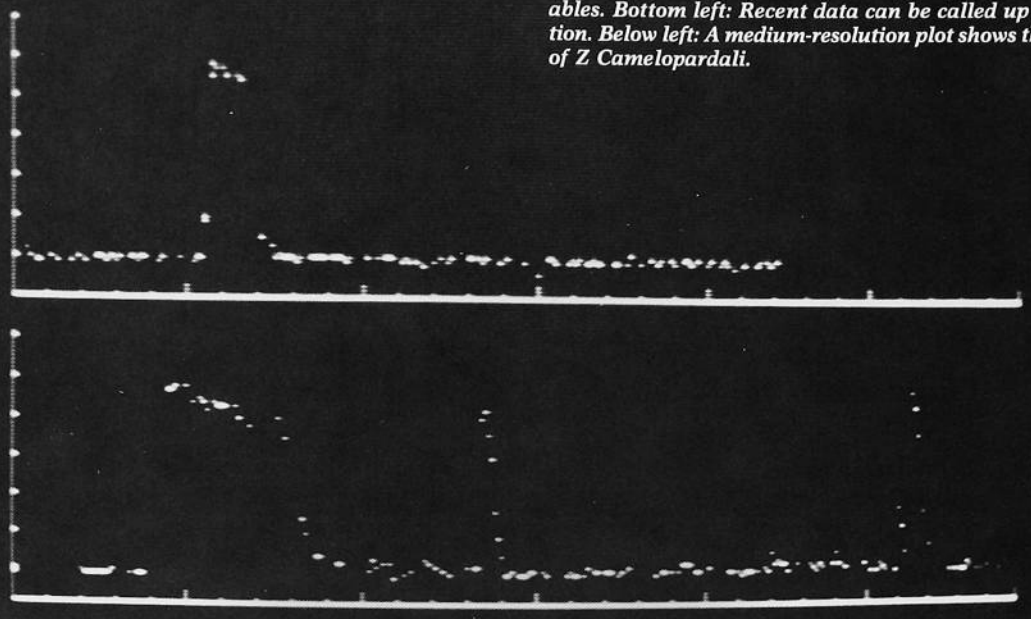
	RX And	51	=132		RZ Leo	94	<142		632 Cyg		
	HT Cas	72	<140		T Leo	94	<140		SS Cyg	44	=118
	TY Psc				YY Dra	72	<142		RU Peg	44	=126
Obs. 62	KU Cas	72	<140		TW Vir	94	*122	123	EZ Peg	51	=095
	KT Per	51	<140		Bc UMa	72	<140		IP Peg	51	<138
	AR And				AL Com	94	<145		DX And	51	<140
	TT Ari				UZ Boo	94	<143				
	UV Per	72	<140		TT Boo	94	<148				
Moon 8	UW Per	72	<140		T CrB	94	=099				
	TZ Per	72	=130		AH Her	94	=136	136			194
	SV Ari	51	<140		RS Oph						93
	AF Cam	72	<140		UZ Ser						133
	GK Per	72	=116		AM Her	94	=133	131			19
	FO Per	51	=133		CH Her						126
Sky hazy/ex	AH Eri				LL Lyr	94	<143				
	HW Tau	72	<140		AY Lyr	94	<142				
	AQ Eri	71	<140		R Set				X Leo	94	<145
	BI Ori	71	<142		CY Lyr	94	<136	low	SY Cnc	94	=128
	CN Ori	71	<140		FO Aql				U Gem	94	=140
	SS Aur	51	<140		KX Aql				YZ Cnc	94	=127
	344 Ori	71	<140		EM Cyg				SU UMa	94	=139
	CZ Ori	71	*124	*126	811 Cyg				AB Dra	94	<137
803	CW Mon	71	<142		1152 Cyg						
	HL CMa	71	<137		542 Cyg						
	IR Gem	71	<142		EY Cyg						

A typical scoresheet of variable star data.

This high-resolution plot of U Geminorum's brightness shows the star's changes over 600 days. Below right: A low-resolution plot of GK Persei shows the star's behavior over a 150-day span. Bottom right: A BASIC program allows input of data concerning variables. Bottom left: Recent data can be called up for fast inspection. Below left: A medium-resolution plot shows the performance of Z Camelopardali.



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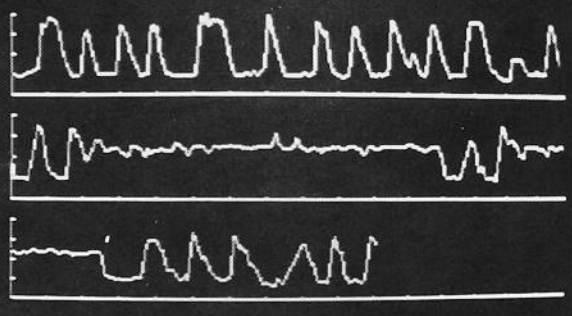

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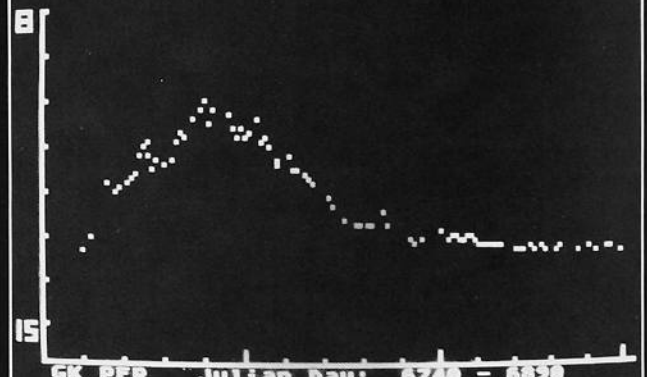


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Gerald P Dyck DCP     Rep #42 Feb 1987
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Dartmouth MA 02747    Time =  G.M.A.T.

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                      830.47  <134
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                      838.47  *107
                      841.47  <130

0058+40 RX And   2446828.46  =135
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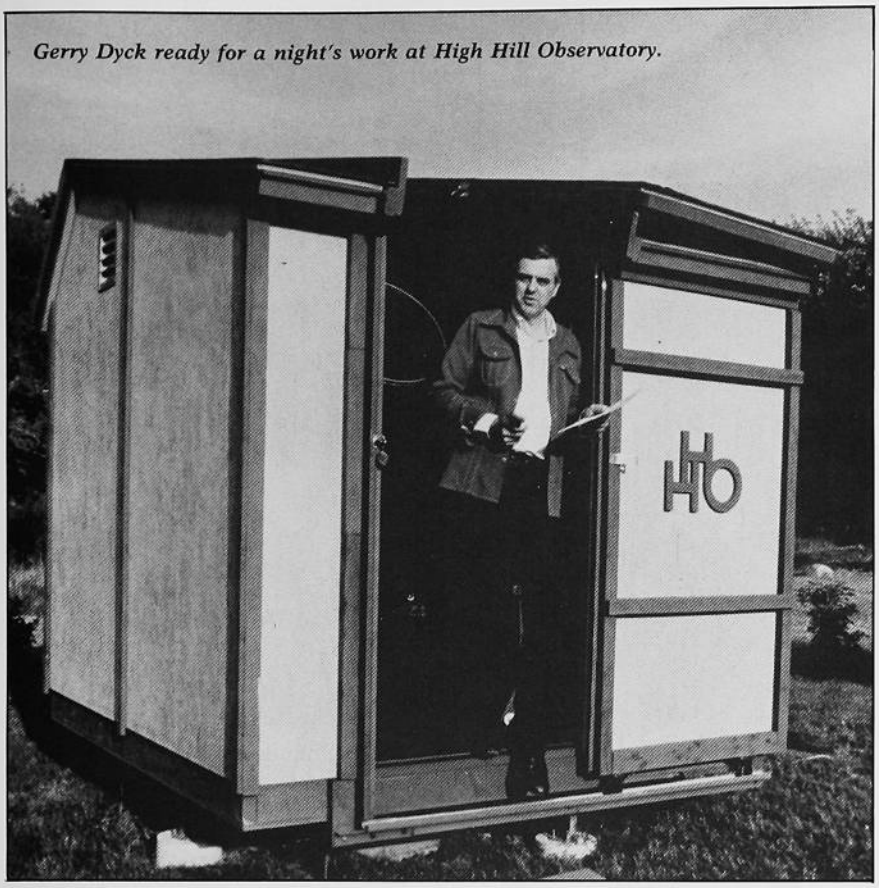

Gerry Dyck ready for a night's work at High Hill Observatory.

the star's position, for each star. For example, I use this saying to find SS Cygni: "Deneb to fourth star in cradle to nearby V-shape opening to steer's head." Of course, after a while I discard the mnemonic, but I never forget the position!

I recommend the "plateau" method for monitoring variables. Start with a few stars and then add a few to your program every month or two. When I find a new star I want to monitor, I practice finding it several times, repeating verbal directions I have made up and inventing names for the star patterns that help me find it. I find a straight-through 50mm finder most useful, and I also use a 4-inch Newtonian RFT to help move through sparse starfields. The Nagler 13mm eyepiece is my bread-and-butter eyepiece because I like the combination of high power (150x) and wide field (30').

From the eyepiece my observations go onto a prepared data form that lists all of my program stars in right ascension order. I enter Greenwich Mean Time, the magnitude of the variable, and the comparison stars used for the estimates. In some cases I extrapolate to the known limiting magnitude of a given night. During some sessions I use a digital stop watch with a lap counter set to beep every 14 minutes and 24 seconds (0.01 day). This is especially helpful when observing a short-term or erratic variable star.

I do most of my observing during the first hour after dusk, and I also observe during the half-hour before bed time or just before dawn. The predawn sessions require the most motivation but are frequently rewarded by rare outbursts, aurorae, meteors, zodiacal light, barium releases, and the glee of "cheating the season."

I first attempted to computerize observational data with two commercial software packages, *PFS File* and *PFS Report*. Although these are worthwhile programs and for some may be excellent tools, they gradually became impractical for me. Then I began writing a program specifically designed for storing and manipulating variable star data. This program has grown and improved over the sixteen months of its development and use. In its present state the program can accept data from daily observations; sort data by star, date, and outburst; plot a light curve for any star, and print out a monthly report in the standard AAVSO format.

The program was written in Atari BASIC and can be used with a disk drive or cassette program recorder. Observations are stored as data lines in abbreviated form for maximum storage capacity. Each data line is a single string in one of these three forms:

- AW G 82048<144
- SY C 62062=126
- SS C 62094*104

These lines consist of star name, first letter of constellation, last three digits of a Julian Day, decimal of Julian Day to two places, symbol (< means fainter than, = means positive estimate, and * means outburst), and magnitude minus decimal point. Harvard designation, full star name and Julian Day are stored in the program and added to the data during printout. The Atari 800XL with 32K RAM can hold 1,500 such lines, which is more than adequate for even the busiest months.

AAVSO observer reports are collected, sorted, plotted, and published by the central office in Cambridge, Massachusetts. In this way each observer makes a small contribution to the total body of data made available to the astronomical community. The home computer, however, also allows me to plot and analyze my variable star data. The plotting process greatly enhances my interest in the stars' activity and the light curves make excellent teaching aids for club talks and discussions. Analyzing the data at home also motivates me to keep at it on cold winter nights.

I plot the activity of stars on three levels according to the graphics capability of my Atari computer. First, my report program can display a graph of data stored during the current month. It is a point graph showing at maximum thirty days of data, so it is of limited use. Using medium resolution graphics, I can display 150-day light curves. At this level it is possible to make curves displaying significant behavioral patterns. High-resolution mode allows me to make light curves for over six hundred days of data. The computer can also predict the dates of future outbursts.

The sound capabilities of the Atari turn flarings and fadings of stars into celestial melodies. Some melodies are extremely static, but those made with the light curves of active stars are worthy of musical attention. Several of these tunes formed the basis of a suite called "Image and Variations," which was performed at the seventy-fifth anniversary banquet of the AAVSO.

The rewards of observing variable stars are many; frequent observing sessions, familiarity with the sky, contribution of data to the scientific community, the satisfaction of being present when a rare outburst occurs, and so on. Occasionally bonuses even occur, like the opportunity to participate in space-based observing runs or to alert astronomers at major observatories of an event. In all these ways I remind myself of the term "amateur" and the German word *Sternenfreund*, which really hits home closely. Variable star observers are some of the truest friends of the stars.

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Small Scope Showcase

Of Cold, Dust, and Gas

by David H. Levy

The Northern Hemisphere winter sky is either too cloudy or too snowy, or on those few occasions when the sky is clear, the night is much too cold for good observing. Often your only hope is to run outside, set up the telescope, and grab a quick look at M42. Making the trek to a darker sky certainly increases the pleasures of viewing, but with an Arctic wind-chill factor you can pay a bitter price in frostbitten skin and all-around misery.

The only way to cope with the problem of winter is to dress warmly and aggressively. When I lived in frigid Montreal, I wore several layers of clothing that could be added or peeled off, depending on the state of the atmosphere (and me). Eventually I conquered the cold by moving to Tucson, Arizona, where nights of subfreezing temperatures are rare. On the other hand, I have to admit that my coldest observing experience actually took place in Arizona. It was a February night on Kitt Peak, where I was observing minor planets. The temperature wasn't too cold, only about 30° F. But we worked in an unheated dome without a break for over thirteen hours. I never knew I could get so cold!

So play it smart. If you are driving a long way to a dark-sky site, always let someone know where you are going and when you plan to return. That way you have a much better chance of being found if an emergency occurs. Once you arrive, step out of the car and get a sense of just how cold it is. Then layer up as much as you think necessary — and always keep at least one more layer in reserve for when your energy begins to flag and the cold really seeps in.

After the telescope is set up, treat yourself to a look at the **Orion Nebula** (M42). A single look at M42 under the clear, dark skies of winter should make you forget about the cold. Some 1,600 light-years away and 26 light-years wide, this fine cloud of primordial gas and dust will glow a ghostly green in your eyepiece. Its central stars, the fourfold Trapezium, form a silvery nugget at the nebula's heart. The bigger your scope, the farther you can trace the nebula's edge, but even in a small telescope it is magnificent.

Around the star Zeta (ζ) Orionis — the star at the eastern end of Orion's Belt — lies an oddly shaped patch of nebulosity. Under a truly dark sky its general pattern can be seen with almost any size telescope. Trailing off to the south of Zeta Orionis is the faint nebula IC 434. This object is difficult to see. Its most famous component, the **Horsehead Nebula**, is not an easy object in any instrument. Even though the Horsehead gets pictured in almost every basic astronomy book, it is one of the hardest objects to see in the winter sky.

Rolf Meier, a well-known observer from Canada, has reported seeing the Horsehead with only a 4-inch f/4 reflector, but this required great skill and superb conditions. I have seen the Horsehead with a 16-inch reflector and an Ultra High Contrast (UHC) filter. These "anti-light pollution" filters can enhance the view by selectively transmitting the light of a nebula while suppressing that of the sky background. The result is an increase in contrast and better visibility for you.

Although the Horsehead is small, the key to seeing it is not high magnification or large aperture as much as moderately high magnifications. (As you'd expect, a UHC filter also works well on the Horsehead because the filter enhances the contrast tremendously.) Be sure to place Zeta outside the field of view, because Zeta's bright light will prevent you from seeing the Horsehead clearly.

Photographing the Horsehead is much easier than seeing it. A 5-minute guided exposure with moderately fast film and an f/ratio around 5 should reveal all the nebulosities around Zeta as well as the Horsehead.

The Horsehead Nebula is dark because there are no nearby stars to light it up or shine through it. We see it only because it is a dust cloud projected against a bright background; if it weren't for the glowing nebula, the Horsehead would be invisible.

About 2° northeast of Zeta Orionis is the reflection nebula **M78** (NGC 2068). Through a small telescope (8 inches or less) M78 looks very much like a comet. In fact, it has long been a kind of test for comet hunters. If your telescope reveals M78 during a comet hunt, then the scope is probably sufficient for hunting comets that are 8th magnitude or brighter. M78 has a sharply defined nuclear region surrounded by a "fan" that extends south. Near M78 are several smaller nebulae — NGCs 2064, 2067, and 2071.

Now comes an object for observers with sharp eyes, low-magnification eyepieces, and lots of patience. If you look about a degree north of M78, you may notice a brightening in the field of your telescope. For me it appears only as a slight brightening of the northern half of the field compared to the southern. This is the brightest part of the huge supernova remnant known as **Barnard's Loop**. Barnard's Loop is easy to photograph but difficult to see. Seeing this object requires an extremely dark sky and clean optics, so the contrast between the nebulosity and the sky is enhanced in every way.

Astronomers know that the entire region of Orion is ablaze with nebulosity because it is a place where new stars are forming — a stellar nursery that seems to be the busiest part of the night sky. Scattered through these nebulae are many variable stars. For example, about 20′ southeast of Chi^1 (χ^1) Orionis, a 3rd-magnitude star in the northeastern part of the constellation, is a variable called **U Orionis**. U Orionis is a long-period variable that ranges from 6th to 12th magnitude in a period of just over a year. Reddish in color, U Orionis was at maximum light in late November 1987 and is well on its way to minimum, predicted for the middle of July 1988. It will be at maximum again in early December 1988. To follow changes in a star like this, compare the variable's brightness to nearby stars.

Although Orion is by far the richest area, you can find beautiful nebulae in other parts of the winter sky as well. In northern Monoceros lie some of the finest small nebulae in the entire sky. One is the **Cone Nebula**, a tapering dust cloud that juts (like the Horsehead) into a cloud of nebulosity about half a degree south of the 5th-magnitude star 15 Monocerotis.

In the north, Cassiopeia is riding high these months; two beautiful and magnificent open clusters, NGC 869 and NGC 884, lie just south of the constellation. Together these are known as the **Double Cluster**. You can spot them without a telescope as a misty spot lying in northern Perseus. This beautiful group of stars looks good in almost any telescope as long as you keep the magnification fairly low. My favorite instrument to see them with is a 6-inch f/4 reflector; its field is perfect to point out the contrast between the rich starfield and its lesser-populated background. About a degree and half north of 884 (the eastern cluster of the pair) is a well-known variable star **S Persei**. The star varies from 7th to 11th magnitude in a not very regular manner; you should compare it to its neighbors once every two weeks.

Above: Open clusters M36, M37, and M38 provide small telescopes with a rich array of stars. Photo by J. A. Farrell (7.5-inch Schmidt camera, 103a-E film, 15-minute exposure with #29 filter). Above right: The Hyades in Taurus are one of the finest star clusters in the sky. Photo by J. A. Farrell (7.5-inch Schmidt camera, Royal Pan film, 5-minute exposure). Right: Galaxy M108 in Ursa Major is a silvery streak of light in small scopes. Photo by Martin C. Germano (8-inch f/5 scope, 103a-F film, 40-minute exposure).

The winter sky is also loaded with open clusters. In the constellation of Auriga lie three famous clusters: **M36, M37,** and **M38**. These clusters differ markedly from one another in texture and density of stars. I see M36 (NGC 1960) as small but clumped, M37 (NGC 2099) as larger and richer, and M38 (NGC 1912) as unclumped and diffuse, even sparse. M37 has a red giant star near its center, a tiny dab of color in a silvery field. These three clusters are certainly worth a look, but Auriga also has other nice small open clusters. One of my favorites is a mix of nebulosity and stars about 3′ across called **NGC 1931**. (It is sometimes mistakenly plotted as a planetary nebula on star charts.) NGC 1931 lies 1° due west of M36 and was the first comet suspect I ever saw.

No cluster, winter or summer, is more remarkable or more exciting than the **Pleiades**. Known from antiquity as the "Seven Sisters," the Pleiades today show six stars to the naked eye under a city sky. In a dark sky, however, you may be able to see as many as eight or ten, depending on how acute your vision is. The Pleiades form a most interesting cluster. One of the closest to us, this cluster consists of some five hundred suns surrounded by very little nebulosity. What little nebulosity they have is dust (not gas) and shines by reflecting the light of the cluster members.

As a cluster the stars appear best in binoculars or at very low powers in a telescope. Moderate magnification brings you in closer and fills the field with bright, sparkly stars. Most appear bluish, which is their actual color. (The cluster is young and has many hot stars.) If we explore with a larger telescope (8 inches or bigger), the Pleiades change again and the view becomes even more exciting. Instead of a cluster we see individual stars and, if the sky is dark and moonless, patches of nebulosity weaving among them.

Not far from the Pleiades is an open star cluster that lies even closer to us: **the Hyades**. The cluster is absurdly easy to find. First, locate Aldebaran, the brightest star in Taurus. Then look at the nearby stars that form a "V" — that's it. The Hyades cluster is truly a naked-eye or binocular object. Looking at it with anything more powerful is a waste because the stars spread over too many fields of view.

The Pleiades and Hyades represent stars in their youth. To see the remains of a star in its old age, we need to go to M1, the **Crab Nebula**. The Crab lies 1° northwest of 2nd-magnitude Zeta (ζ) Tauri and is all that's left of a supernova that erupted nearly a thousand years ago. Ancient Chinese records indicate the supernova exploded (for us on Earth, of course) on July 4, 1054. For several weeks it shone far brighter than Aldebaran and was even visible in daylight. It must have been very impressive, for not only the Chinese but some American Indians saw and recorded it in pictographs on the rock walls of canyons in the Southwest.

You can find the remains of this supernova simply by centering your finder scope on Zeta and then scanning slowly northwest 1°. Look for a faint diffuse object in the low-power eyepiece of your telescope. When you think you've found it, try a medium-power eyepiece because the Crab is not very large. If you are observing from the city, the nebula will be difficult because it is diffuse and its surface brightness is low. If you're out in the country, however, you will be able to see a marvelous, delicately structured cloud. (The Crab nickname came from the nebula's irregular outline.)

Let's end by looking at the Big Dipper, which on late winter nights is riding high in the sky. This region is cluttered with hundreds of faint galaxies, only one or two of which are visible with a small telescope. **M108** (NGC 3556) is a thin, 10th-magnitude smear of light 1-3/4° southeast of the star Beta (β) Ursae Majoris. It is a distant galaxy, but it shares that corner of sky with something in our own Galaxy, the **Owl Nebula** (M97). The Owl measures about 3′ in diameter and glows at 11th magnitude; it lies 3/4° farther to the southwest than M108. The Owl is a planetary nebula, the gaseous remnant left when a star sheds its outermost layer late in its evolution.

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My Last Ten Doubles

by Glenn F. Chaple, Jr.

Two issues ago we celebrated the tenth anniversary of *Deep Sky*. I joined the old *DSM* soon after its birth and this column is my last before turning the double star section over to Brian Skiff.

To celebrate, I thought I'd give center stage to my favorite ten double and multiple stars. Highlighting ten out of the 1,500 double stars I've observed isn't easy, and I'm forever changing my mind anyway! So let's just say that these are my *current* favorites.

1. Zeta (ζ) Ursae Majoris, **Mizar**

Mizar is a sentimental favorite because this was my first double star. Its stars of magnitudes 2.4 and 4.0, separated by 14.4″ in position angle 151° (measured in 1967). (2000.0 coordinates: 13h23.9m, +54°56′)

2. Alpha (α) Ursae Minoris, **Polaris**

Polaris is my favorite small scope light-test, although in anything of 3 inches or larger aperture (and with good seeing), it isn't difficult. Polaris A has an average magnitude of 2.0 (it's a Cepheid variable: the magnitude varies from 1.92 to 2.07), while the companion, 18.4″ away in p.a. 218° (1955), is magnitude 8.8. (2h31.8m, +89°16′)

3. Beta (β) Cygni, **Albireo**

Albireo is a long-celebrated pair with beautiful gold and blue colors that have charmed many a skywatcher. Being a fairly wide double, it can be split in nearly any size telescope. Albireo's magnitudes are 3.2 and 5.4 and the separation is 34.3″ in p.a. 54° (1959). (19h30.7m, +27° 58′)

4. **Epsilon^{1,2} ($\varepsilon^{1,2}$) Lyrae**

Besides providing two pairs for the price of one, Lyra's Double-Double is a fine resolution test for small-aperture (3-inch or larger) scopes. Epsilon^1 is the northern half of the pair; its magnitudes are 5.1 and 6.0 and the separation is 2.8″ in p.a. 359° (1966). Epsilon^2's magnitudes are 5.1 and 5.4; separation 2.2″ in p.a. 98° (1966). (18h44.3m, +39°40′)

5. Gamma (γ) Arietis, **Mesarthim**

To me, Gamma Arietis (sometimes called Mesarthim) is the finest example of a twin, or matched, double. (Another is Gamma Leonis.) It always looks like the headlights of a distant automobile. Magnitudes are 4.8 and 4.8; their separation is 7.8″ in p.a. 0° (1969). (1h53.5m, +19°18′)

The Trapezium lies in the heart of the Orion Nebula and is one of the most spectacular double stars in the sky. This photo shows all six components of Theta^1 Orionis and also the twin stars of Theta^2 Orionis at lower right. Photo by Jack Marling, who used a 24-inch f/15 Cassegrain on Mauna Kea, Hawaii, and a 30-second exposure on ISO 400 film.

6. **h1470 Cygni**

This joins three similar-looking pairs to form an eye-catching arc of double stars. Its magnitudes are 7.3 and 9.4; the separation is 28.8″ in p.a. 337° (1925). (20h03.7m, +38°20′)

It is also a favorite for purely egotistical reasons. Subsequent to my reporting this group in *DSM*, one reader nicknamed it "Chaple's Arc" in an article he wrote for a club newsletter. Though the IAU will never recognize the nomenclature, I will always enjoy looking up at my little piece of cosmic real estate!

7. **Theta^1 (θ^1) Orionis**

The Trapezium is easily the finest multiple star in the sky — and being located in the middle of the Orion Nebula doesn't hurt either. Theta's magnitudes are 5.4 and 6.8, separation 13.3″ in p.a. 61°; other components are

at 6.8 magnitude (variable) at 13.1″ in p.a. 311° and 8.0 (variable) at 16.8″ in p.a. 342°. All measurements date from 1925. (5h35.3m, −5°23′)

8. Epsilon (ε) Pegasi, **Enif**

Why is Enif, an easy, wide optical pair, one of my favorites? This duo combines magnitudes 2.3 and 8.5 at 142.5″ in p.a. 320° (1913). It produces a startling pendulumlike oscillation of the fainter star whenever the telescope is gently rocked in a direction perpendicular to a line joining both. Don't believe me? Try it and see for yourself! (21h44.2m, +9°52′)

9. **70 Ophiuchi**

If you want to see the orbital motion of a binary star, 70 Ophiuchi is your best bet. Right now the position angle is decreasing by a whopping 15° a year! Its magnitudes are 4.3 and 6.0; separation is 1.6″ in p.a. 250° (1988, calculated from orbital elements). But the close separation means you'll need a 4-inch or larger scope — and good seeing — to split them. (18h05.5m, +2°30′)

10. **Σ817 Orionis**

To me, this double, shining bravely outside the glare of the great star Betelgeuse, epitomizes the delicate beauty of faint double stars. Its magnitudes are 8.2 and 8.3; the separation is 18.5″ in p.a. 73° (1925). (5h54.9m, +7°02′)

A list of honorable mentions should include h3945 in Canis Major, 95 Herculis, Beta (β) Monocerotis, Alpha (α) Geminorum, and the "Gamma Gang": γ Delphini, γ Virginis, and γ Andromedae.

Deep Sky has grown a lot in the ten years since this column began. For the multitudes of you who weren't subscribers then and missed that first column, here it is the way it looked.

DOUBLE TAKES: As I said above, this is my last double star column for *DSM*. Why am I departing? The main reason is I just don't observe double stars with the fervor I once did. In recent years I have become a full-time variable star observer. (Blame David Levy for that.) It strikes me therefore that the tenth anniversary of this column is a nice time to take my bow. It's also comforting to know that with Brian (and Canadian observer Paul Brown, who will assist him), this column is in very capable hands.

A grateful thank you to all those loyal readers who sent in letters chock-full of notes and sketches of double stars. Please do the same for Brian too! And, of course, special thanks to Dave Eicher, who created *DSM* and left a page or two in each issue for this column. Clear skies to you all.

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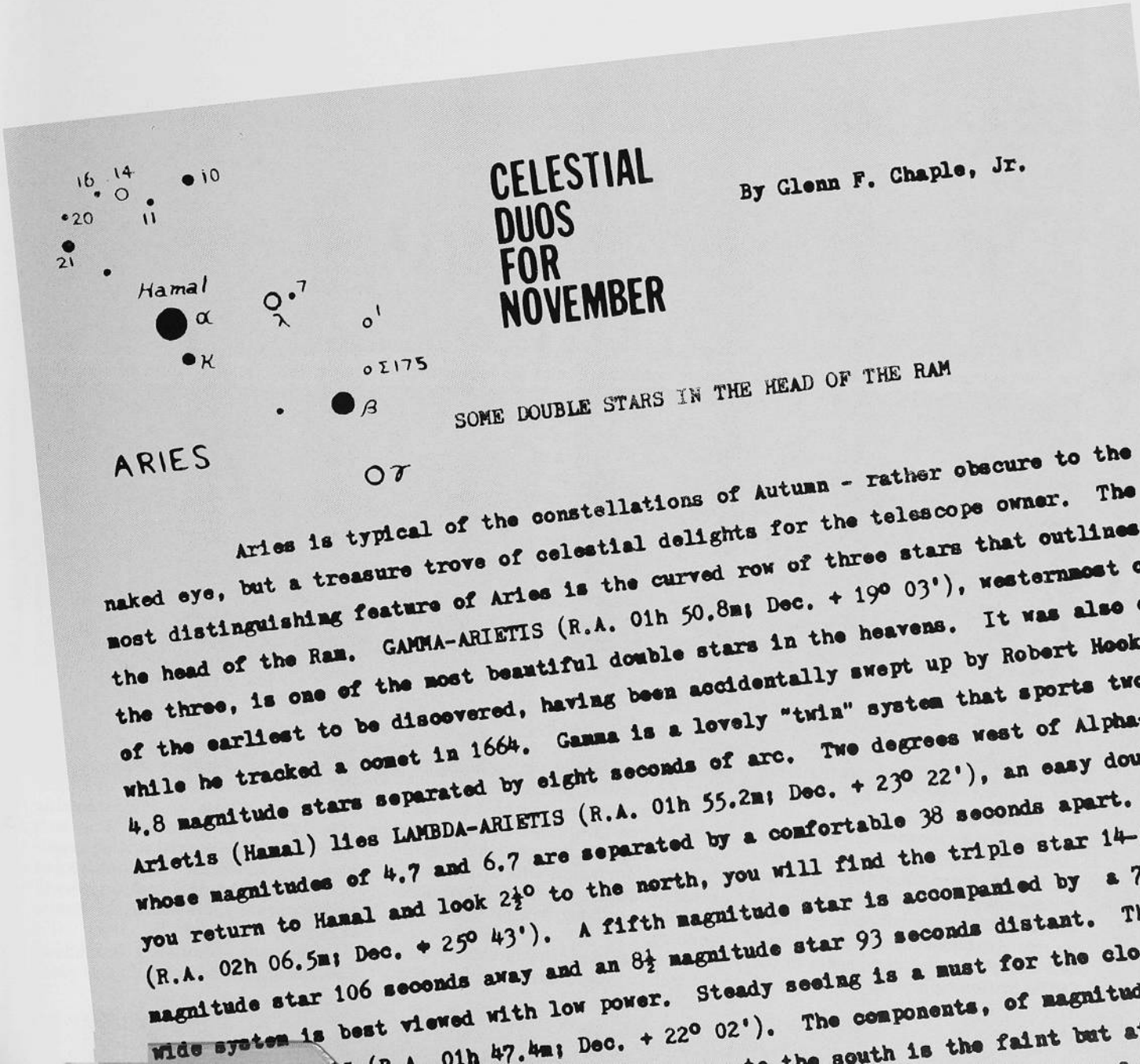


CELESTIAL DUOS FOR NOVEMBER

By Glenn F. Chaple, Jr.

SOME DOUBLE STARS IN THE HEAD OF THE RAM

Aries is typical of the constellations of Autumn - rather obscure to the naked eye, but a treasure trove of celestial delights for the telescope owner. The most distinguishing feature of Aries is the curved row of three stars that outlines the head of the Ram. GAMMA-ARIETIS (R.A. 01h 50.8m; Dec. + 19° 03'), westernmost of the three, is one of the most beautiful double stars in the heavens. It was also one of the earliest to be discovered, having been accidentally swept up by Robert Hooke while he tracked a comet in 1664. Gamma is a lovely "twin" system that sports two 4.8 magnitude stars separated by eight seconds of arc. Two degrees west of Alpha-Arietis (Hamal) lies LAMBDA-ARIETIS (R.A. 01h 55.2m; Dec. + 23° 22'), an easy double whose magnitudes of 4.7 and 6.7 are separated by a comfortable 38 seconds apart. When you return to Hamal and look 2½° to the north, you will find the triple star 14-A (R.A. 02h 06.5m; Dec. + 25° 43'). A fifth magnitude star is accompanied by a 7½ magnitude star 106 seconds away and an 8½ magnitude star 93 seconds distant. The wide system is best viewed with low power. Steady seeing is a must for the close (R.A. 01h 47.4m; Dec. + 22° 02'). The components, of magnitude to the south is the faint but at

Searching for New Stars

by David H. Levy

Even though our knowledge about them is limited even today, supernovae in our own Galaxy have been well observed. Throughout history civilizations have recorded strange events that took place in the sky — the most prominent of these events were bright comets and supernovae. Chinese records give us enough information that we can pinpoint the date of one such supernova as July 4, 1054. Chinese astronomers observed this "guest star" in Taurus, visible even in daylight, for more than a year.

Besides the event of 1054, several supernovae have appeared in our Galaxy over the last millenium. The most famous was observed by Tycho Brahe in 1572. Although he was not the first to see the "new star," Tycho observed it carefully and kept excellent records of its positions and brightness. Tycho was so stunned to see this interloper in a sky he had been taught was forever unchanging, that he wanted other people to confirm that his eyes were not deceiving him.

The supernova outshone Venus and for several weeks could be seen by day. Tycho's Star lay close to Kappa Cassiopeiae and even today we are not certain which of two faint stars in the field is what remains of his supernova. Johannes Kepler, Tycho's student and later his colleague, observed another supernova only a short time later in 1604. Kepler's star was in Ophiuchus.

The supernova of 1604 is the last to have been witnessed in our Galaxy. The brightest supernova since supernova 1604 is the one now visible in the Large Magellanic Cloud. It was discovered in February by Ian Shelton, a Canadian astronomer who was observing at Las Campanas, Chile. Developing a photograph of the Large Magellanic Cloud, he noticed what he thought was a defect in the emulsion. When he went outside to take a look, he saw a bright star near the Tarantula Nebula.

It didn't take long for the rest of the astronomical community — and the world — to learn about the explosion. A star as bright as 4th magnitude would be discovered independently by many sources. Astronomers, both professional and amateur, raced once again to the Southern Hemisphere to see an object of major astronomical interest.

I spent three days in Acapulco where SN1987A reached a mere 3.5° above the horizon. Steve Edberg and I arrived in Acapulco only to find a depressing layer of clouds. On the first night we were able to get a brief and tantalizing glimpse of the supernova. On the second night we drove inland to escape the coastal haze but lost out because the supernova was just blocked by a distant mountaintop. On that second night we got a view of Eta Carinae, another interesting variable star, surrounded by a magnificent cloud of gas and dust. Eta Carinae is a star that may have as much as 150 times the mass of the Sun and is losing one solar mass per year. On two occasions in the last two hundred years this star has risen to brighter than 2nd magnitude. It is a unique star, classified as a "novalike variable."

On the third day the weather changed in Acapulco and we decided to stay to increase our chances of success. Some clouds gathered that evening but not enough to keep us from seeing the Tarantula Nebula and a bright red 4th-magnitude star nearby — the supernova! By this time the supernova had turned red but had not faded significantly since its first appearance almost a month earlier.

There is a profound difference between a supernova and the much more common — and far less violent — stellar explosion that produces an ordinary nova. A typical nova occurs in a double star system in which matter is transferred toward a smaller but denser star and gets deposited in a disk around it known as an accretion disk. As matter falls onto the disk, the place the matter hits becomes extremely hot and at intervals undergoes a nuclear explosion. Depending on how much material ignites, such an event can be quite spectacular. In 1975 Nova Cygni rose about eighteen magnitudes, but it did not stay at maximum brightness for more than two days.

Two or three times each year a visible nova erupts somewhere in our Galaxy. So far as we know a nova does not destroy the system that creates it. In fact, novae often recur. Astronomers know of some novae that have exploded several times. T Coronae Borealis, a star visible now in the morning sky, erupted in 1866 from a minimum of 10th magnitude to 2nd. Another star, RS Ophiuchi, has exploded several times this century.

Brian Marsden, the director of the Central Bureau for Astronomical Telegrams of the International Astronomical Union, has claimed the most valuable thing an amateur astronomer can do is to discover a nova early in its outburst. You never know whether the next suddenly appearing bright star is an ordinary nova or the beginning of the next galactic supernova.

Searching for novae in our Galaxy involves becoming completely familiar with all stars down to a certain brightness level. It sounds all but impossible, yet, in fact, it isn't too difficult to learn the sky, year-round, down to 3rd magnitude — there are only a few hundred stars to know. If you are very persistent, sometime within the next fifteen to twenty years you may discover a nova that is 3rd magnitude or brighter.

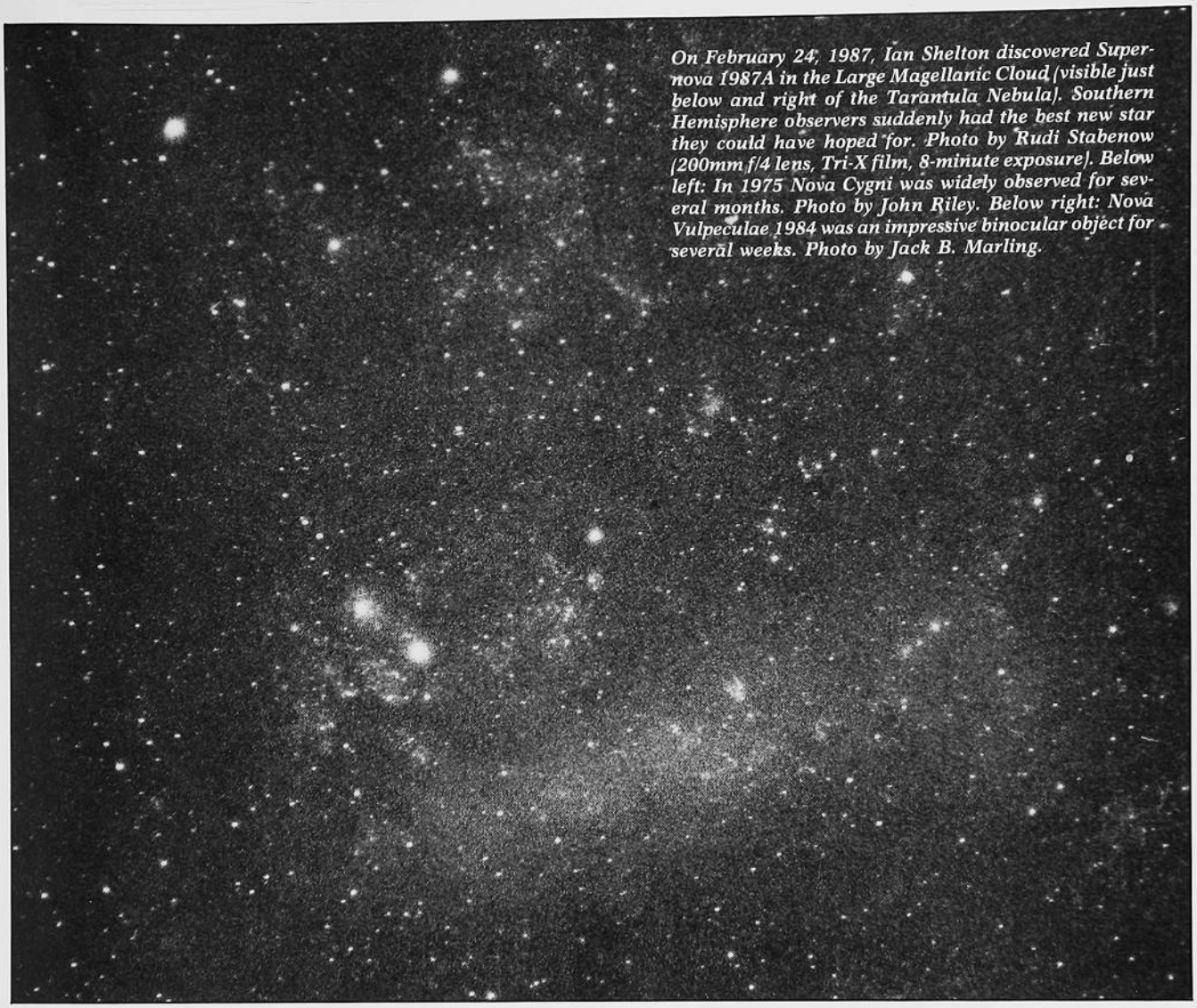
If you hope to cover the sky down to 4th, 5th, or 6th magnitude, your chances become much greater though, of course, learning the sky is much more difficult. Peter Collins has discovered two novae, one in 1978 in Cygnus and one in 1984 in Vulpecula. Collins searches in patterns. He divides the areas of the sky through which he will search into artificial "constellations," little patterns he can become familiar with. His objective is to discover an interloper in one of these areas.

Robert Evans has been more successful than anyone else in discovering supernovae in other galaxies. As of February 1987 he has found fifteen. His procedure is to become so familiar with the telescopic appearance of galaxies (by viewing galaxies frequently) that he can instantly detect when one of these galaxies sports a new star.

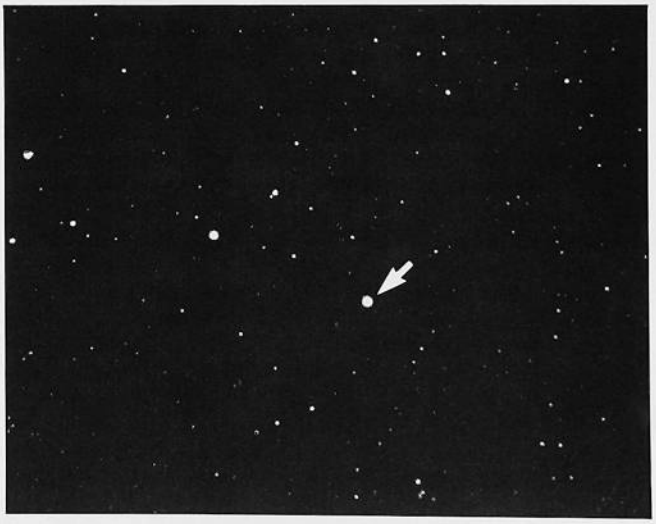
The search for supernovae is complex because a galaxy may actually change its appearance from night to night, depending on the conditions of our atmosphere and on the telescope you are using. On a night of unusually good seeing you may spot a detail in a distant galaxy where a bright region — a super-Orion Nebula, say — looks like a faint star or bright star that has just appeared.

When patrolling the sky, persistence is everything. As in any worthwhile project, the sky will probably reward the person who observes the most nights and misses as few searching opportunities as possible. It is true people have discovered novae, supernovae, and comets serendipitously, but you can't expect that will happen to you. Form a definite plan and follow it through.

Where is it best to look? I recommend the summer Milky Way in the areas



On February 24, 1987, Ian Shelton discovered Supernova 1987A in the Large Magellanic Cloud (visible just below and right of the Tarantula Nebula). Southern Hemisphere observers suddenly had the best new star they could have hoped for. Photo by Rudi Stabenow (200mm f/4 lens, Tri-X film, 8-minute exposure). Below left: In 1975 Nova Cygni was widely observed for several months. Photo by John Riley. Below right: Nova Vulpeculae 1984 was an impressive binocular object for several weeks. Photo by Jack B. Marling.



closest to the center of the Galaxy (Sagittarius, Ophiuchus, Scorpius, Serpens, Vulpecula, Cygnus, and even Hercules). These constellations are favorites because more stars are there, more than in the winter Milky Way of Cassiopeia and Perseus — although Perseus yielded a very famous nova, GK Persei, in 1901.

A supernova can occur in any galaxy, but supernovae tend to occur more often than not in spirals. Moreover, when searching for supernovae, concentrate on the period when the Moon is out of the sky.

An exploding star in our Galaxy could be an ordinary nova or it could be the next galactic supernova, simply hidden by a lot of dust. It is important for amateur astronomers to search the sky for these objects, for it is in the earliest hours of the explosion that the star reveals its deepest secrets.

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Scanning the Literature

August-October 1987

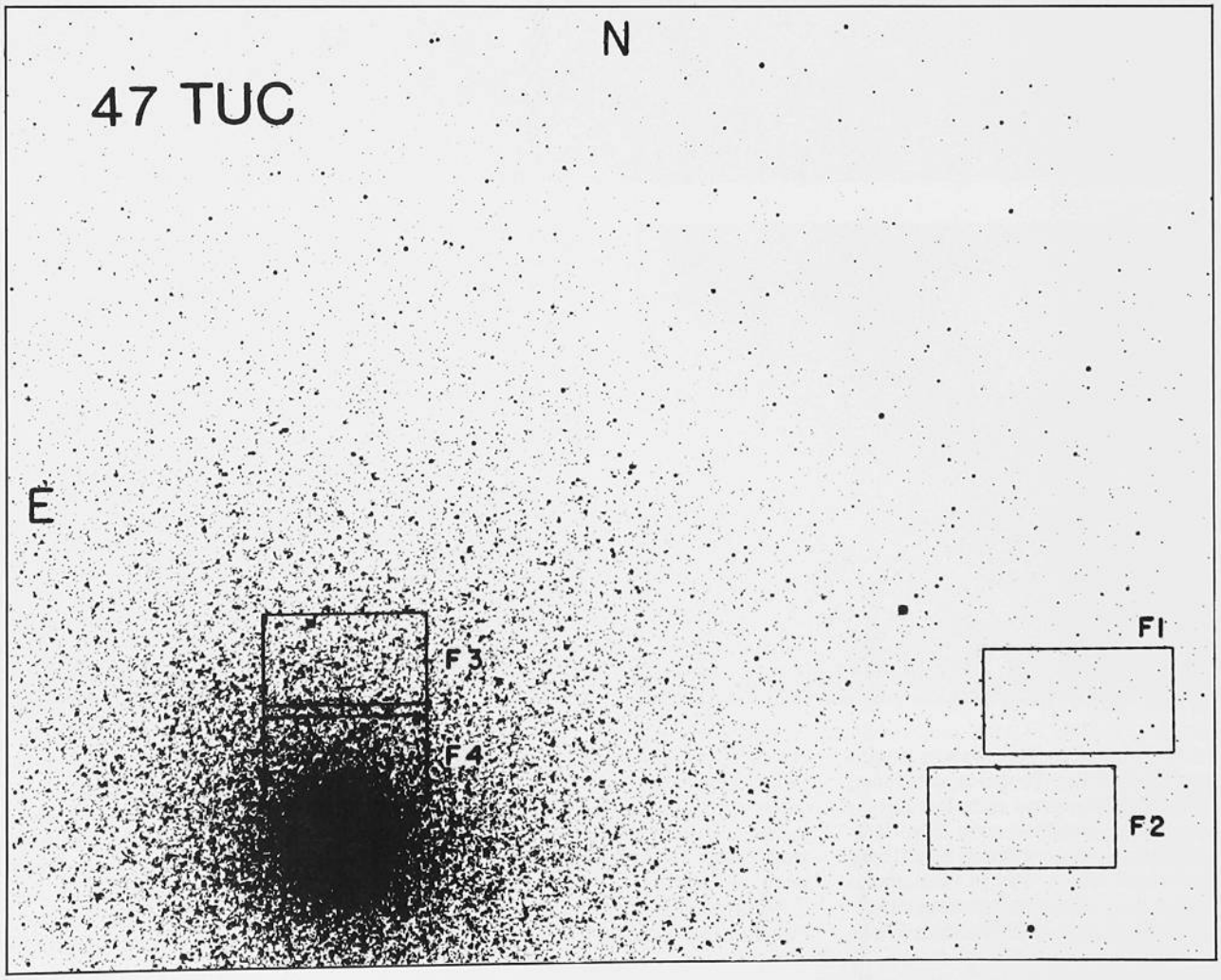
The August 1987 issue of the *Publications of the Astronomical Society of the Pacific (PASP)* was thicker than usual because of a sixty-page article by a group of Canadian astronomers led by Jim Hesser ("A CCD Color-Magnitude Study of 47 Tucanae," *PASP* **99**:739). The globular cluster 47 Tucanae, also catalogued as NGC 104, is the second brightest globular in the sky after Omega (ω) Centauri and a naked-eye object for Southern Hemisphere observers. The authors took four exposures with a CCD camera at the prime focus of the CTIO 4-meter telescope. These yielded BV photometry for 8,800 stars (!), the data for which would take up many closely spaced pages in a table.

Unusual care was taken in reducing the CCD images to magnitudes and colors, and further carefully made exposures of standard stars allowed transformation to the standard photometric system. Even so, the data are good to only 0.05 magnitudes brighter than V magnitude 22; below this the data are still useful but only for statistical purposes.

The final color-magnitude diagram was fit to an extensive grid of models of stellar evolution by Don VandenBerg (one of the co-authors). This work suggests an age of 13.5±2 billion years and a distance of 4.8 kiloparsecs. The main sequence of the cluster is very narrow and shows no evidence for any binary stars, which would appear as a string of points parallel to the curve of the main sequence but about 0.75 magnitude above it.

Two large catalogues of southern galaxies have appeared since the publication of the *Second Reference Catalogue of Bright Galaxies (RC2)*, which came out in 1976. That work presented dimensions for galaxies at a well-defined surface brightness level that has subsequently been adopted as a uniform standard for galaxy work.

Now, measures in the two newer catalogues have been calibrated against this standard in preparation for the *RC3* (*Standard Photometric Diameters of Galaxies III*). Reduction of the diameters in the ESO-B and SGC catalogues to the standard diameter system at the 25-magnitude arcsec^{-2} brightness level (G. Paturel, P. Fouque, A. Lauberts, E. A. Valentijn, H. G. Corwin, and G. de Vaucouleurs; *Astronomy & Astrophysics*, **184**:86, October I). The ESO and SGC catalogues are based on inspection of deep-sky survey plates from the ESO and UK Schmidt telescopes and thus give dimensions corresponding to a limiting surface brightness between magnitudes 26 and 28 per square arcsecond — a much lower brightness level than the standard one. Consequently, the sizes of galaxies measured with this system must be greatly reduced to transform them to the RC2 system. This was done by comparing sizes of a large number of "standard" galaxies, which have well-established dimensions, with the ESO/SGC measures. The compari-



son was not trivial, as both catalogues showed trends in the measured sizes that depend on the type (elliptical or spiral), overall size, and degree of elongation of the galaxies involved. The article, written by those responsible for all three catalogues, gives equations to put the newer measures on the RC2 system.

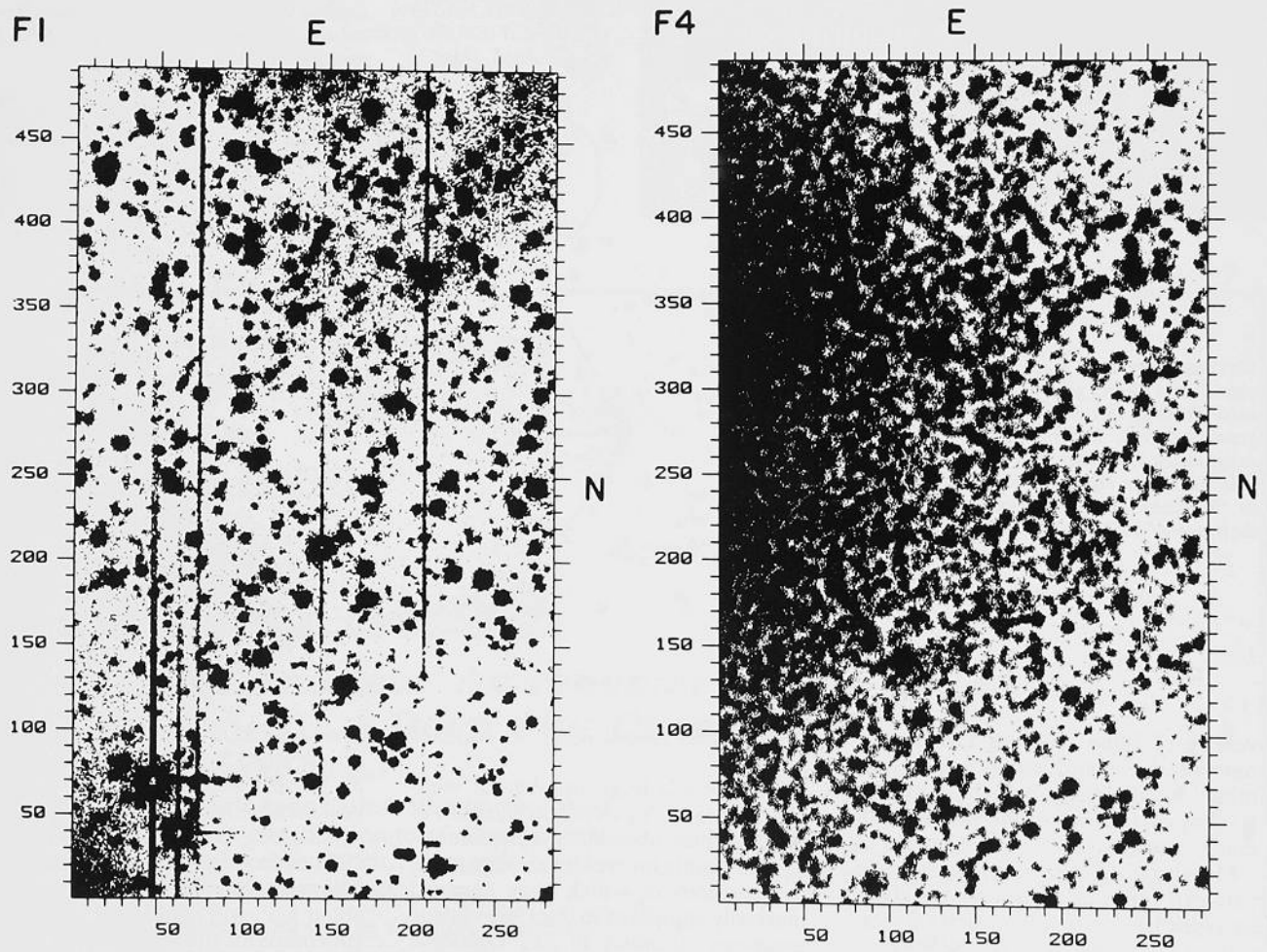
As more and more amateurs seek out small, faint planetary nebulae, they soon buck up against the limitations of existing catalogues. The true natures of the 1,500-plus reported planetaries have not all been verified — and it's easy to go astray. About one in six of the reported objects is shown to be a probable nonplanetary in a paper by Agnes Acker and a number of collaborators ("Misclassified Planetary Nebulae" in *Astronomy & Astrophysics Supplements* **71**:163, October). The article summarizes information already in the literature, data from *IRAS*, and new data taken by the authors for 266 objects.

The intent is to sort out the confusion of H II regions, symbiotic stars, Me stars (cool stars with emission lines such as some Mira variables), emission-line galaxies, and other weird, pathological objects that have been called planetary nebulae. Among NGC/IC objects the following can be noted:

5408	= galaxy
6164-5	= H II shell around a young star
6857	= compact H II region
IC 2120	= H II region
4662	= emission-line (dwarf?) galaxy

Speaking of H II regions, a long-standing need is for photometry of stars involved in these regions. Spanish astronomer J. F. Lahulla is making an effort in this area. "Observations of Stars in H II Regions: UBVRI Photometry," (*Astronomical Journal* **94**:1062, October) is the second paper of what one hopes will be a long series. Lahulla used the 1.5-meter telescope on Calar Alto in Spain to measure several stars in each of eight Sharpless H II regions. The article includes finder charts for each field adapted from the POSS. Approximate distances to the nebulae are derived, and in a few cases the exciting star is identified for the first time.

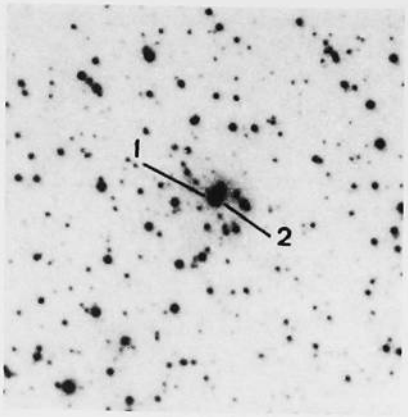
A work that should prove extremely useful to variable star observers is "An Atlas and Catalogue of Northern Dwarf Novae" by A. Bruch, F. J. Fischer, and U. Wilmsen (*A&A Supplements* **70**:481, September). This fine atlas includes ninety dwarf novae north of +20° declination and complements a similar atlas of equatorial and southern objects by Nick Vogt and Frank Bateson. For most stars, three charts (15'by 15') are given: one during quiescence, another during an outburst, and one from the POSS showing very faint stars in the field. The first two images were taken with a 30cm astrograph or a 50cm Schmidt at the Hoher List Observatory of the Uni-



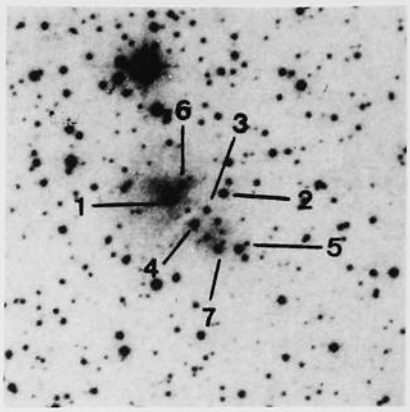
Left: A group led by Jim Hesser of Canada's Dominion Astrophysical Observatory recently conducted a CCD color-magnitude study of the great globular cluster 47 Tucanae with the 4-meter telescope at Cerro Tololo Interamerican Observatory in Chile. The published results in Publications *of the Astronomical Society of the Pacific suggest an age of around 13.5 billion years and a distance of 4.8 kiloparsecs for the cluster. This photo shows four CCD fields used in the study, two close to the cluster's center and two some distance away.*

Above: Two CCD fields from different sections of cluster show radically different numbers of stars, although F1 is a long exposure and F4 a short exposure. The positions of these fields, which measure 5' by 3', are visible at left.

Spanish astronomer J. F. Lahulla's multicolor photometry of stars in H II regions, published in the Astronomical Journal, *has produced distances for several gaseous nebulae in the Sharpless catalogue. Two stars in S61 (right) helped to determine a distance of 1.7 kpc for the cloud. Six stars in S219 (far right) — star 2 is not associated with S219 — gave a distance of 4.5 kpc.*



S 61



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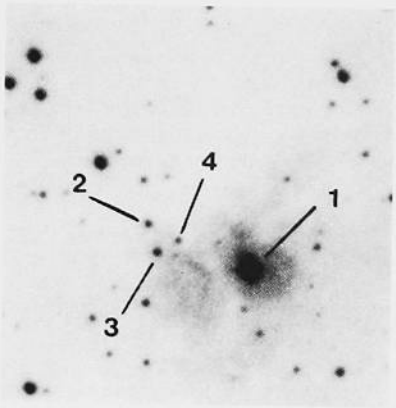

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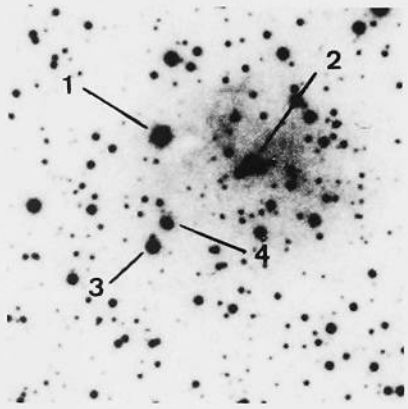
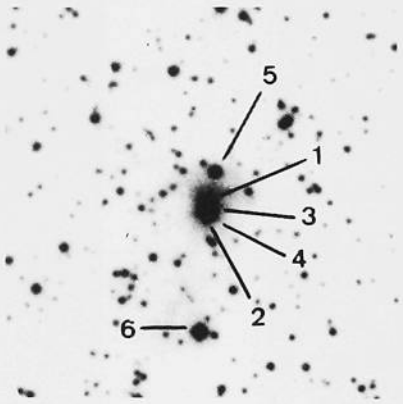


S 267

By studying stars in the faint reddish nebulosity S242 (far left), Lahulla calculated the nebulosity's distance as 2.5 kpc. Star 1, a B-type main-sequence star, appears to be the illuminating star. S267 (left) contains two stars from the study, which showed this nebula to be 4.5 kpc. Star 2, an O-type main-sequence object, is the exciting star.

Star number 1, a B-type main-sequence star, is the object that excites S285 (right) into shining. Star 5 is probably a foreground object, but the others helped in estimating this nebula's distance as 6.4 kpc. S299 (far right) glows from two stars in the Lahulla study, which showed the distance of S299 to be 6.1 kpc.



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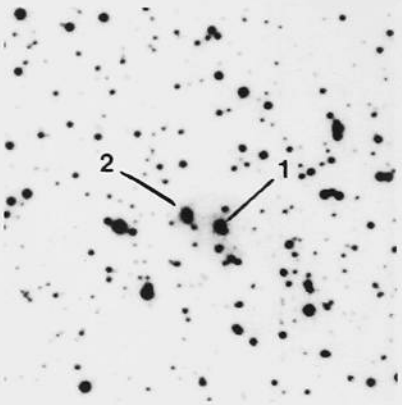

S 299

versity of Bonn. Besides the photos, new precise coordinated were determined for all objects, which made substantial corrections to the literature in many cases.

Measures of 1,300 double stars made between 1984 and early 1987 are given by Wulff Heintz in "Micrometer Observations of Double Stars and New Pairs. XIII" (*Astrophysical Journal Supplements* **65**:161, September). The measures were made with the 24-inch refractor at Swarthmore College in Pennsylvania and with the 36- and 60-inch telescopes at CTIO in Chile. Over one hundred new pairs are reported, none of which is easy for modest apertures because of faintness (magnitude 10 or 11 typical) or closeness (about 0:3″) for brighter pairs.

However, a large number of well-observable ADS pairs form the bulk of the list. These observations provide up-to-date results for rapidly moving pairs, the positions of which have changed markedly compared to the 1960-vintage measures common in *Sky Catalogue 2000.0*, volume 2, and other older sources such as Burnham's *Celestial Handbook*.

A new orbit for a moderately close pair has been computed by J. L. Houser ("Orbit and Parallax of Sigma 1819," *PASP* **99**:509, June). Revised values for the parallax, proper motion, and orbital motion are presented for Σ1819, also known as ADS 9182. The pair of magnitude 8 GO V stars lie at a distance of 37 parsecs and move about 0.2″ per year across the sky. The orbit uses measures going back to Struve's original 1830 observations. The period is about 220 years; the maximum separation of about 1.5″ will occur next in 2105. An ephemeris for the remainder of the century follows.

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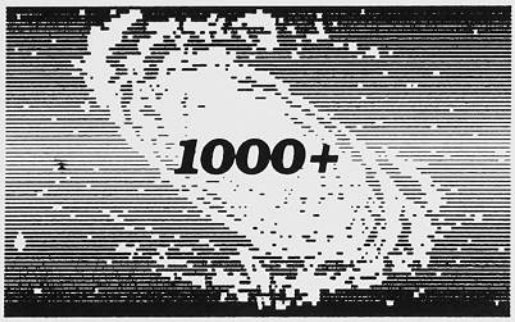

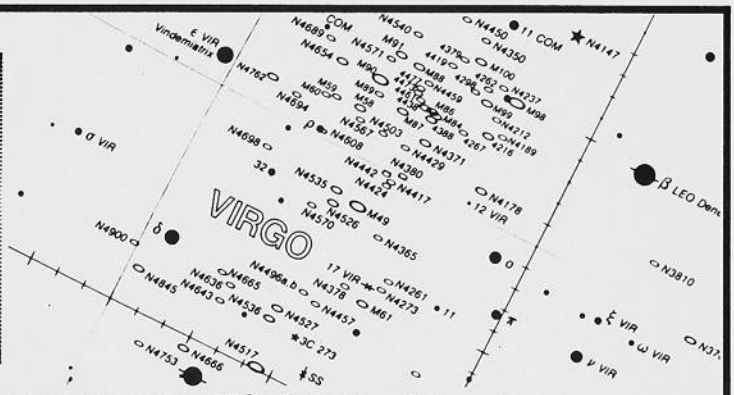

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Photo Feature

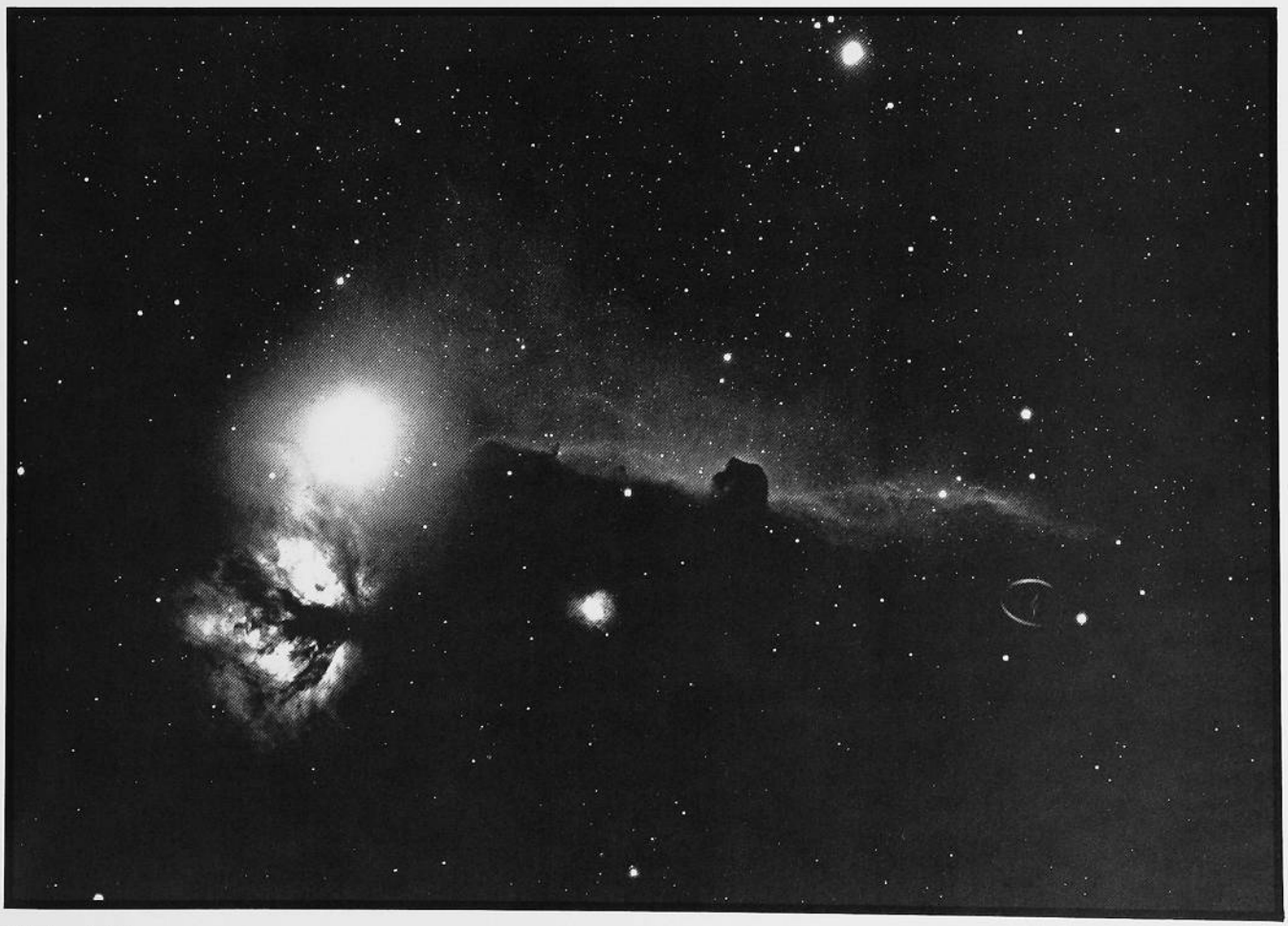
Mike Sisk of Helena, Arkansas, is one of the most enthusiastic and well-equipped astrophotographers in the country. Recently he began taking photographs with a custom-built 16-inch Schmidt camera that produces stunning results, many of which we hope to publish in the future. Here is a sampling of bright objects from Mike's file of test shots.

Right: The Whirlpool Galaxy, M51, in Canes Venatici.

Opposite page, top: Central region of the Andromeda Galaxy including satellites M32 and NGC 205.

Opposite page, bottom: The Horsehead Nebula, Barnard 33, in the sword of Orion.

Below: The Lagoon Nebula in Sagittarius along with the tiny globular cluster NGC 6544.



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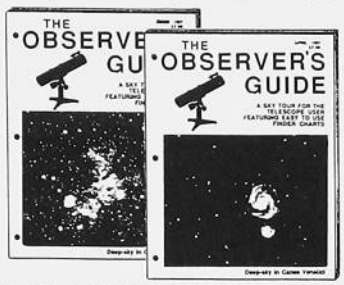

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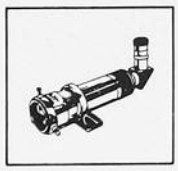

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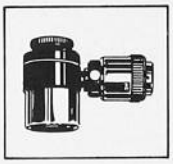

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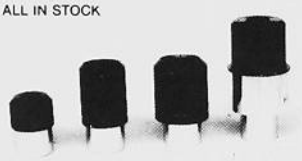

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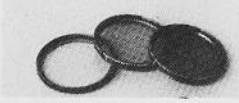

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Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm		**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece		**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece		**$20.00**

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. Not always available. Include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

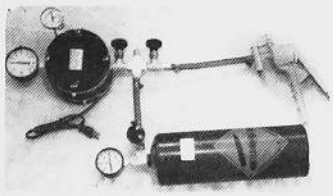
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7" Has 2 gas cylinders and includes temperature controller .. **$595.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump, Model R-10 **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent # 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$79.50**
Illuminated reticle eyepiece system .. **$89.50**
Guider for Hasselblad **$350,** Mamiya 645 **$199**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$185,** Mamiya 645 **$159**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**
GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$195,** Mamiya 645 **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$89.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.
2. Cable release for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) .. $70
NEW Deluxe Digital Qtz. Drive Correc. **$298**

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	$10.95
SR1600, fastest of all, color neg	24	$12.95
Konica SR200, fine grain color neg	12	$9.95
3M 1000, fastest slide film	20	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
5072, color slides from neg	36	$6.95
D-19 B&W Developer	1 gal.	$6.95

Meade®

8" and 10" LX5 Schmidt-Cassegrains

Scan the Moon at the Touch of a Button with Advanced Meade High-Speed Scanning Electronics.

Meade 8" Model 2080/LX5 and 10" Model 2120/LX5 Schmidt-Cassegrains are designed to meet the requirements of the most discriminating observer and astrophotographer. No other commercial telescopes include such extensive *standard-equipment* features:

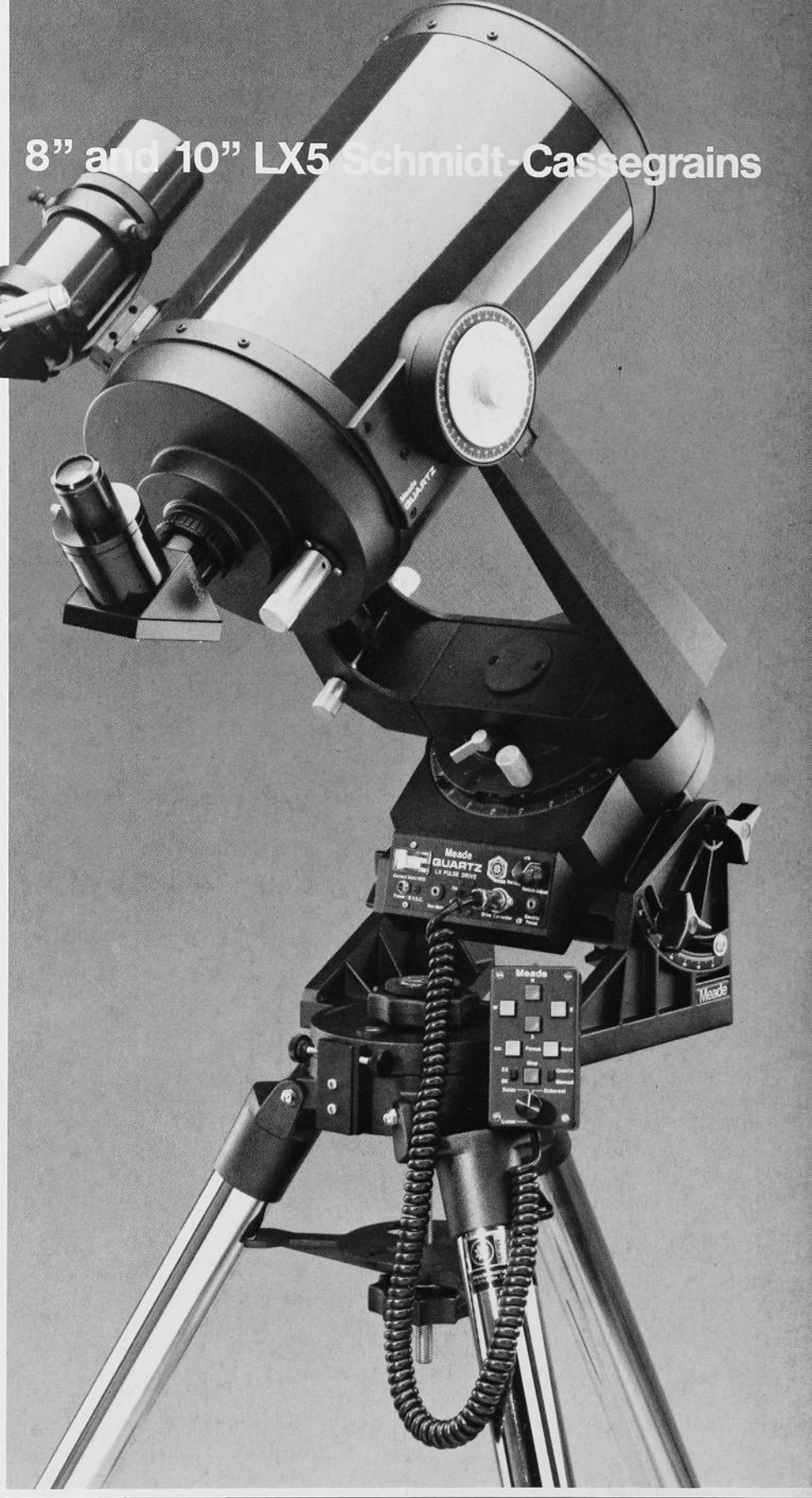
☐ **Electronic Command Center:** This hand-held controller puts virtually all telescope functions at your fingertips! Flip to the 8X Scanning Speed and you're roving over the lunar surface, or touring the Orion Nebula, at high speed. Add the optional Declination Motor for full dual-axis capability and you'll probably never use manual RA and Dec controls again! Use the 2X Correction Speed for micro-guiding corrections during astrophotography.

☐ **Power Panel Display:** Monitor telescope operations at a glance. Panel modules include **(a) Ammeter,** to gauge battery life during power cell operation; **(b) North-South Switch,** permitting operation of the telescope anywhere in the World; **(c) 12-volts DC Power Inlet,** with power cords for operation from auto cigarette lighter plugs, 115v. AC outlets, or from the included battery pack, using AA-size batteries supplied by the user.

☐ **Other features** include a **Quartz/Pulse Electronic Drive System,** the most precise available on any commercial telescope; 1/10-wave-flat, multi-coated **2" Diagonal Mirror,** accepting both 1¼" and 2" OD eyepieces; **9 x 60mm Polar Illuminated Viewfinder;** the Meade **Multi-Coated Optics Group;** and a superb **Super Plossl 26mm eyepiece.**

Best of all, Meade 8" and 10" LX5's include legendary Meade diffraction-limited optical systems—the finest available from any manufacturer.

For full details, send $3.00 for your copy of the Meade full-color General Catalog #87D. We'll also include a copy of the Meade 36-page **Accessories Catalog and Observer's Guide.**



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